VOL. XXIII. JULY, 1913. NO. 3.

THE MONIST

CHRISTIAN ELEMENTS IN THE MAHABHARATA, EXCEPTING THE BHAGAVADGITA.[1]

IN the question with regard to the influence Christianity has exerted upon Brahmanism, one of the two great epics, the Râmâyana, is not to be taken into consideration, for it was certainly composed before the Christian era and even its later insertions are not later than the second century after Christ;[2] then too the home of the Râmâyana is in the eastern part of India. The case is different with the Mahâbhârata whose composition extended over at least a millennium. We now know, to be sure, that the Mahâbhârata gradually attained its enormous size for the most part during the period between the fourth century B. C. and the fourth century A. D.,[3] nevertheless it contains not only portions which originated before this period but also single additions of a later date. Georg Bühler's opinion that the Mahâbhârata had attained the final form in which we now have it by the sixth or seventh century is hardly disputed to-day. Accordingly the historical possibility that Christian elements might have entered into our Mahâbhârata text is granted without hesitation; but there is only one

[1] Authorized translation from the German manuscript by Lydia G. Robinson. In the bibliographical references the following abbreviations will be observed: ERE, *Encyclopædia of Religion and Ethics*; IA, *Indian Antiquary*; JAOS, *Journal of the American Oriental Society*; JRAS, *Journal of the Royal Asiatic Society.*

[2] Winternitz, *Geschichte der indischen Litteratur*, I, 427 ff., especially 439, 440.

[3] *Op. cit.*, I, 389 ff.; especially 396, 403.

single portion that can be said with any certain degree of probability to betray acquaintance with Christian doctrines and Christian worship. This is the legend of the Shvetadvipa, the "White Island," or the "Island (i. e., the land) of the White People" (Mbh. XII, Chapters 337, 338, ed. Calc.).

All competent critics agree that judging from its whole character this passage must belong to the latest interpolations of the great epic. Kennedy[4] places it in the fifth or sixth century; on account of considerations to be given later on I feel compelled to decide in favor of the sixth, and lay stress on the fact that this date which is essential for my explanation of the passage can not be assailed on critical grounds. If this portion really contains an evidence of contact between Brahmanism and Christianity it at the same time provides a proof of the fact that at the time and in the country where the final redaction of the Mahâbhârata took place—in the interior of Northern India —there was as yet no knowledge worth mentioning of the teachings, the worship and the communal life of Christianity; for otherwise this religion would not have seemed so strange and wonderful to the author of the Shvetadvîpa episode.

THE SHVETADVIPA EPISODE.

I must say in advance that not by any means all specialists acknowledge the Christian basis of the Shvetadvîpa legend, but that Barth,[5] Hopkins[6] and others see in it merely an evidence of poetic fancy. I myself formerly advocated this standpoint[7] and have only recently reached

[4] JRAS, 1907, 481.

[5] *Religions de l'Inde*, 132.

[6] *Religions of India*, 431, 432. Nevertheless in *India Old and New*, 161, Hopkins regards as possible a purely external relation with the Christians in Herat or Merv which was brought about by travels.

[7] Translation of the Bhagavadgitâ, Introduction 30.

the conviction that Lassen,[8] Weber,[9] Grierson,[10] Kennedy,[11] etc. are right in finding in this portion the traces of an acquaintance with Christianity.

Briefly stated the content of the legend is as follows: The Mahâbhârata relates in the first of the two chapters under discussion that the wise Nârada has been to Shvetadvipa and from there has brought back the Pâñcharâtra doctrine proclaimed by the god Nârâyana (which must be discussed later). In the second chapter the three sons of the god Brahma, Ekata, Dvita, and Trita (i. e., Nos. 1, 2, and 3) took the same journey together with the seven Rishis. Shvetadvipa is more than thirty-two thousand miles (*yojana*) northeast (Mbh., XII, v. 12703) or north (v. 12774) of the mountain Meru on the northern bank of the Milky Sea. The white luminous inhabitants of this land are supernatural beings; they have no sense organs, they live without nourishment, they exhale rare perfumes and are without sin. With their glance they blind the eyes of sinful men and are endowed with other fabulous peculiarities, such as four testicles, sixty normal teeth, and eight fangs (v. 12706). These superhuman beings worship in their hearts the *one* invisible God Nârâyana with softly murmured prayers and hands always folded (v. 12787) and are filled with supreme love for him (v. 12798). None among them occupy exalted positions but all enjoy equal consideration (v. 12790). These latter statements indeed make the impression that they are based upon contact with a Christian community, but I have not been able to discover a description of the eucharist service which Grierson tries to find in this chapter.[12]

[8] *Indische Altertumskunde*, II, 2d ed., 1118-1119.

[9] In many passages; see my translation of the Bhag. Intro. 30 note.

[10] ERE, II, 549*a* and elsewhere.

[11] JRAS, 1907, 481 ff.

[12] Pratâpa Chandra Rây's translation of the Mahâbhârata, Shântiparvan, II, 752 note; Grierson, JRAS, 1907, 316.

The entire legend of Shvetadvîpa is full of unheard-of fancies, behind which however there seems to lurk an actual knowledge of a Christian country. In favor of this view we have, besides these features relating to worship and society which we have just mentioned, the account of the direction (northeast or east) in which Shvetadvîpa is supposed to lie. In spite of this distinct statement Albrecht Weber with almost incomprehensible stubbornness has for decades maintained the assertion that the account of the Mahâbhârata becomes intelligible only when it is recognized to contain traditions of the journeys of pious Indians to Alexandria and the acquaintance with Christianity which they gained there. Because of its location Alexandria cannot of course be considered, and I will not stop to waste words with regard to other utterly foolish localizations. Lassen, who at any rate came nearer to the truth than Weber, probably had Parthia in mind,[13] where some Brahmans may have become acquainted with Christianity and from where they may have brought Christian doctrines to India; but his argument, based on the age of the tradition that St. Thomas had spread the Gospel in this country, will not hold good.

Kennedy has recently made an attempt to determine more exactly the location of Shvetadvîpa.[14] He proceeds from the fact that the statements about its location are too definite for an entirely imaginary country; they could only indicate a land on the other side of the great mountain ranges, Bactria or probably a region lying still farther north, perhaps the banks of Lake Issyk-Kul "where there is an abundance of frozen sea," by which evidently the mythical Milky Sea is to be understood. Kennedy bases the last assumption on the fact that numerous Nestorian communities had dwelt on the southern shore of Issyk-Kul.

[13] Page 3, Note 3.
[14] JRAS, 1907, 482.

But Issyk-Kul can not come into consideration in our attempt to identify the Indian Milky Sea, for the following reasons. In the first place this lake is not so far from India as we would expect from the statements of the Mahâbhârata with regard to the immense distance; in the second place it is not so large as to give the impression of an ocean; and in the third place it never freezes over because of its surprisingly warm water. The Kirghiz name *Issyk-Kul* denotes "warm lake" as does also its Chinese name *She-chaj*. The "abundance of frozen sea" can therefore in no wise suffice to give the lake in winter the appearance of a milky surface.

It seems to me that the more remote Lake Balchash[15] has a much greater claim to identity with the Indian Milky Sea, for to-day it covers about twenty thousand square kilometers or about the same size as the kingdom of Württemberg. *Balchashi Nor* is a Kalmuck expression and means "great water." Various indications go to show that once in earlier times a much larger lake spread over where now Lake Balchash lies.

The idea that Lake Balchash is the Indian Milky Sea becomes intelligible from its Kirghiz name *Ak-Dengis*, "white ocean."[16] This name is scarcely derived from the fact that the lake is covered with ice from the end of November until the beginning of April, but may be accounted for in the following way. Lake Balchash is extraordinarily shallow and, according to the measurements of the Russian geographer L. S. Berg who for the first time examined the lake with some precision in the summer of 1903, it has a maximum depth of only 11 meters. This greatest depth of Berg's measurements is to be found in the western half, and although according to other apparently

[15] My information with regard to this lake I owe to the kindness of my geographical colleagues, Gradmann and Uhlig.

[16] Egli, *Nomina Geographica* (Leipsic, 1872) in the article "Balkaschi Noor."

reliable information there are said to be places in the eastern part as much as twenty meters deep, yet taking the lake on the average, it is not nearly so deep; particularly the southwestern corner and the whole southern bank are extremely low. Berg characterizes the water as muddy,[17] earlier informants call it clear. But this contradiction signifies nothing, for the water of so shallow a fresh-water lake would be stirred by the wind to its very bottom and would *assume a milk-white color.* This, combined with the size and the position of Lake Balchash, makes it correspond excellently with the Indian Milky Sea.

Then when we consider that the most important of the ancient trade-routes of Central Asia led from Samarkand over Tashkent to Kuldsha and Turfan on the south side of Lake Balchash and that the Nestorians had long before sent their missionaries far into Central Asia, then nothing hinders the assumption of Nestorian settlements on Lake Balchash in the sixth century—about a century and a half after the establishment in the year 411 of the Christian church of the Sassanid empire from which such colonies must have proceeded. The land of seven rivers, once famous for its fertility, on the southeast bank of the lake was densely inhabited in earlier times; especially on the Karatal and Ajagus rivers there are said to be many ruins of ancient civilization. The assumption is obvious that in later days these old settlements fell as a sacrifice to the nations of the Steppes or even to the advancing encroachment of the sand.

Prof. Th. Nöldeke wrote me November 6, 1911: "In the region south of Lake Balchash Nestorian communities of some size existed as late as in the thirteenth and fourteenth centuries. We know this from the very numerous gravestones inscribed with Syriac characters and for the most part in the Syriac language—though dreadfully cor-

[17] A. Woeikow in *Petermann's Mitteilungen,* XLIX (1903), 285.

rupted—and partly in Turkish, as the people without doubt spoke Turkish and knew the Syriac only as the language of the church."[18] The two places containing Nestorian churchyards, Pishpek and Tokmak, lie on the slopes of Mt. Alexander quite close to the southern point of Lake Balchash.

That Nestorian communities with a regular clergy existed in these regions at so late a period is evidence at any rate that Nestorians found there in earlier times a flourishing abiding place.

From all I have adduced, the identity of Lake Balchash with the Indian Milky Sea gains at least as much probability as can be attained under the circumstances.[19] Therefore I do not hesitate to state my conviction that Nestorian colonies which originated in the sixth century on the shore of Lake Balchash furnished the foundation for the Shvetadvîpa legend of the Mahâbhârata.

Since Bardesanes,[20] as early as the beginning of the third century, mentions the presence of numerous Brahmans in Bactria, there is no objection to assuming that the account upon which is based the fabulous description of Christian worship and communal life on the banks of the Milky Sea was brought through Bactria to northwestern India. But this information has not been of special significance for the religious life of India, for no new ideas are involved which might have come with it into India. As we shall see later, the idea of divine love and submission to God is traceable in India at a much earlier time. In the story of Shvetadvîpa the author has intended to give only

[18] Chwolson, *Syrische Grabschriften aus Semirjetschie*, Mémoires de l'Ac. Impér. des Sciences de St. Pétersbourg. VII Series, Vol. XXXIV, No. 4, St. Petersburg, 1886, and *Syrisch-nestorianische Grabinschriften aus Semirjetschie*, new series presented to the academy February 28, 1896. St. Petersburg, 1897.

[19] If my identification is correct the older Indian legends of the Milky Sea, especially of its whirling, must be based upon obscure information with regard to Lake Balchash.

[20] In Eusebius, *Praepar. Evang.*, VI, 10 (ed. Gaisford, Vol. II, p. 83, l. 2).

one proof from outside for the doctrine that divine love is the most certain way to supreme salvation. Nor has the Shvetadvîpa story exerted any actual influence on later Indian literature; only in one legend of the Kûrmapurâna, according to which Shiva in the Himalayas had propounded the Yoga system to his four disciples Shveta, Shvetâshva, Shvetashikha and Shvetalohita, and in a very similar story of the Vâyupurâna, can remote echoes of our episode be found.[21] In connection with these legends we can scarcely think with Weber[22] of a Syriac-Christian mission which might have settled in the Himalayas. Still less significant than these legends is the fact that in the modern Krishna and Râma ritual and in the quite late commentary of Svapneshvara to the Shândilyasûtras attention is given to the Shvetadvîpa story.[23] It is a reckless overvaluation when Weber[24] says that there can hardly be any doubt that the worship of Krishna in India to-day is essentially based upon those pilgrimages accounts of which are preserved to us in the Shvetadvîpa story.

THE ATTITUDE OF E. WASHBURN HOPKINS.

I have said above on page 322 that the Shvetadvîpa legend is the only part of the Mahâbhârata in which Christian influence can be assumed with any degree of probability. Hopkins[25] sees a whole series of further possibilities which however do not stand closer inspection, and rest moreover upon the erroneous assumption that Christian missionaries had already been actively engaged in northwestern India ever since the first century. There is no proof of the presence of Christians in India before the first half of the third century.

[21] Lassen, *Indische Altertumskunde,* 2d ed., II, 1119; Wilson, *Selected Works,* III, 148 f.

[22] *Indische Studien,* I, 421, note; II, 398; *Krishnajanmâshtamî,* 322.

[23] Weber, *Krishnajanmâshtamî,* 321.

[24] Ibid. 319, 320.

[25] *India Old and New,* 152 ff.

Although Hopkins prudently emphasizes "how remarkably similar may be *by mere chance* the phraseology of different religions" (p. 150), and although he confirms the warning which lies in these words by bringing forward a number of remarkable parallels between the Veda and the Old Testament,[26] none of which can be suspected on one side or the other of being either source or copy, yet he is not restrained by his own warning from deducing the possibility of a historical connection from the boldest combinations. He is evidently imbued with the desire to find Christian influence in the Mahâbhârata and especially in the Bhagavadgîtâ (of which we shall speak in another article) and to have Krishnaism appear dependent upon Christianity at the earliest possible date. To be sure he makes some limitations as we should expect from so thoughtful a scholar, as for instance when on page 159 he "lays no great weight upon parallels which show a possibility of Christian influence," or, on page 160, gives them "for what they are worth." Then too Hopkins is always very careful in his expression when stating the parallels, but nevertheless the whole presentation is calculated to exert a suggestive effect upon the laity and to arouse faith in a far-reaching influence of the New Testament upon the Mahâbhârata. Considering the importance of the subject and the attention which Hopkins's essay has found in wide circles, I am obliged to enter a decided protest against it and therefore may not limit myself to these general observations but must enter more closely into particulars than I would prefer.

BORN OF A VIRGIN.

In Hopkins (page 159) we read: "Krishna is a by-name of Vyasa, the author of the epic (in so far as the arranger of the mass my be called author), who, though

[26] Partly following Kaegi, *Der Rigveda*, 2d ed., 63 ff.

not identified with Krishna as Supreme God, is himself divine, and is described as '*the unborn* (that is, the eternal) *and ancient one, the only son of God, born of a virgin, very part, ança of God.*' He is a figure unknown till the end of the epic, and even his name Vyasas, *vyâsas,* has a certain similarity with *iêsos.*"[27] But *Vyâsa* is a good Indian word and denotes "the arranger." The seer who bears this name is not only looked upon as the arranger of the masses of the Mahâbhârata but of the four Vedas as well and also as the author of the Purânas. Not only the conclusion of the cited passage, where the possibility of the loan of the name is derived from such an accidental and unimportant verbal similarity as can easily be alleged in hundreds of cases from the most different languages, but the whole statement lacks the objectivity and critical acumen to which we are otherwise accustomed in the works of Hopkins. In this opinion, which holds good also for the succeeding comments upon Hopkins, I have in mind mainly the passage I have italicized above, which is intended to make a Christian impression. This quotation Hopkins has pieced together from parts of three different verses of the Mahâbhârata (XII, 13640, 41, 88, ed. Calc.) in order to bring them into accord with Christian ideas! Of course for this purpose the epithet "born of a virgin" is particularly striking. But what is really the case with regard to it? I think I can give the best account of the fantastic story of the birth of Vyâsa in the words of Winternitz:[28]

"He was the son of a famous ascetic, the Rishi Parâshara. One day this great saint saw the maiden Satyavatî who had come into the world in a fish and had been reared by fisher folk, and he was so enraptured by her beauty that he besought her love. She would accede to

[27] Of course Ἰησοῦς is meant.

[28] *Geschichte der indischen Litteratur,* I, 268, 269.

his wishes only on condition that after bearing him a son she might again recover her virginity. The holy man granted her this wish as well as that she was to lose her fish odor and to exhale a marvelous fragrance. Directly after their union, she bore him a son upon an island in the Yamunâ and the boy was called Dvaipâyana, 'the island-born.' He grew to manhood and soon devoted himself to a life of asceticism, but Satyavatî having resumed her virginity became later the wife of Shântanu, the king of Kuru."

It is for this reason, therefore, that Vyâsa was called the "son of a virgin" (*kânîna*) although his birth was brought about by natural procreation; and yet Hopkins, who was surely acquainted with this story from his intimate acquaintance with the contents of the Mahâbhârata, tried to see in it a parallel to the legend of the supernatural birth of Christ!

THE DIVINE SACRIFICE.

After the sentence here criticized Hopkins continues: "Then of the God Krishna it is said: 'He, the guardian of his flock, the sinless God, the Lord of the world, consented to the death of (himself and) his race that he might fulfil the word of the seers,' where, if we had shepherds and prophets, the comparison would be very striking."

This quotation from the Mahâbhârata (XVI, 161-163; ed. Calc.) deals with the destruction which as a result of a curse of Gândhârî had befallen the Yâdava race whose leader was Krishna. The men fell to quarrelling in a drunken bout and slew each other with clubs; but Krishna himself was mistaken in the forest for an antelope by a hunter with the name Jara, "old age," and was slain by an arrow in his only vulnerable spot on the sole of his foot.[29] The verses quoted by Hopkins, which Vasudeva, the human father of Krishna, speaks, read as follows in a literal

[29] Winternitz, *op. cit.*, I, 317.

translation: "You....recognized Govinda (the winner of herds, i. e., Krishna) as the eternal, sinless, imperishable God; and this my son who was the mighty Vishnu himself (i. e., in whom Vishnu had become incarnate) looked upon the destruction of his own race and permitted it to take place. He, the Lord of the world, desired that the word of Gandhârî and the Rishis should not appear vain, O oppressor of the enemies." Who with unprejudiced judgment could consider Christian influence even possible in this utterance and in the act to which it refers? Hopkins inspires—unconsciously of course—the appearance of such an influence by the suggestive addition "of himself," and by the Christian coloring of the wording of his translation. Krishna did not perish with all his house for the purpose "that he might fulfil the word of the seers," but in order that a genuine Indian curse might be fulfilled as occurs in Brahman narrative literature with annoying frequency.

THE UTTERMOST PARTS OF THE SEA.

Hopkins continues: "Another passage..., close to biblical phraseology, may be found in the description of the avenging spirits: 'If thou goest into the depths of the earth, or if thou shouldst fly above, or if thou fleest to the further side of the sea, still thou shalt find no escape from them' (Mhb. IV, 428); as compared with the psalmist's words, 'Whither shall I fly....into heaven....Sheol.... the uttermost parts of the sea?' (Ps. cxxxix. 7 ff.)."

Might not this passage in the Psalms equally well be compared with the verse, many centuries older, in the famous Varuna hymn of Atharvaveda (4, 16, 4): "Whosoever were to flee far away from heaven, could not escape from Varuna the king," and would we not have to see in this parallel a new warning against the attempt to found

a loan hypothesis upon such similarities of expression?[30] Here too we must not consider the verse of the Mahâbhârata apart from the situation to which it is related. Kîchaka wishes to seduce Draupadî, but she rejects him and threatens him with the revenge of her five husbands who are Gandharvas. And now just imagine how the poet in describing *this* situation could have had in mind a verse of the Psalms and have depended on that whereas throughout the whole context of these stories not a single trace of biblical influence can be found! To the possible objection that we should consider that such biblical phrases had already been adopted at this time in Brahman India, and might have been used even without remembering their source, it may be answered that, apart from the great intrinsic improbability, the extraordinary scarcity of really striking parallels in the Mahâbhârata argues against it. There is not the slightest reason to question the Indian originality of such passages.

The next quotation, "Thou seest the faults of others, though they be no larger than mustard, but thine own faults thou canst not see though they be as large as a bilva tree" (Mbh., I, 3069) indicates only such a uniformity of *thought* with the familiar passage in the Bible, as can be accounted for on general considerations, but not the characteristic figure of the moat and beam in the eye.

THE SAINT ON THE STAKE.

Hopkins then brings forward at the end of the paragraph a very singular parallel: "Even the crucifixion has its analogy in the story of the Stake-Saint (impaling being the equivalent of crucifixion), who was unjustly impaled with thieves, but he did not die like the thieves and so awakened the wonder of the royal guard. They went and told the king, who was frightened when he heard of it

[30] See above, page 329.

and came to the Saint on the Stake and besought his forgiveness, which was granted as the king had acted ignorantly. He is besung in all the worlds as the Impaled One.... It is perhaps not impossible that there is here the echo of Christian story." On the contrary it is quite impossible and entirely excluded. It is only necessary to examine more closely the story in the Mahâbhârata (I, Chaps. 107, 108) in order to find that the only similarity to the crucifixion of Christ consists in the fact that it is an innocent man who is executed. This has happened often enough on earth, and has proved an effectual theme for narrative in the literature of all nations. In our case even the manner of death is not the same.

The Indian story is as follows: For many years Mândavya, the anchorite, has sat in front of his hermitage with upraised arms observing the vow of silence. One day robbers pursued by the police come running up and hide their booty in the hermitage, concealing themselves near by. The pursuers ask the hermit which way the robbers fled and of course receive no answer from him. Soon they catch the thieves and find the booty in Mândavya's hermitage, whereupon he is suspected of complicity with the robbers, is brought before the king, and sentenced to death. The executioners impale Mândavya, but he still continues to live by virtue of his asceticism although he receives no food, and by this same virtue he summons other saints who come at night in the form of birds and sorrowfully ask him for what guilt he is obliged to suffer the martyrdom of impaling. Mândavya answers: "Upon whom shall I lay the blame? No one else (but myself) brings this upon me." The king receives the information that Mândavya keeps alive in some miraculous way, and hastens to beg his pardon and to have the stake of martyrdom taken down. But when he tries to draw the stake from the body of the hermit he is not successful, and therefore cuts it

off at the surface of the body. Mândavya goes away bearing in his body the point of the stake during the rest of his life, and continues to practise his efficacious asceticism. But from that time on he was known throughout the entire world as Anî Mândavya, "Mândavya with the peg." One day he betook himself to the abode of Dharma, the god of justice, and asked the deity seated upon his heavenly throne for what unwittingly committed sin he now had to endure such horrible suffering. Dharma told him that the punishment was because once when he was a child he had pierced insects in the back with a reed. Thereupon Mândavya cursed the god that he should be born again as a Shûdra, because he had inflicted so disproportionately severe a punishment for a childish misdemeanor. The curse was of course fulfilled.

Is not the genuinely Indian impression of this fantastic tale most obvious? Can we conceive of a larger number of characteristically Indian features than the type of the hermit, the supernatural power of his asceticism which performs impossible miracles and in the face of which the gods themselves are powerless, the idea of unfailing retaliation for every deed and the inevitable curse at the end? How can a scholar otherwise so clear sighted, who comes to the conclusion that there is no historical connection in the hundred times greater similarity of New Testament narratives with their *Buddhist* parallels consider it even possible to find in the story just related an echo of the account of the passion of Christ?[31] It becomes psychologically comprehensible only through a religious temperament which is instinctively impelled to discover transmissions from Christianity. Who seeks such reasons for Christian influence on the Mahâbhârata gives the best

[31] In his *Religions of India*, p. 432, Hopkins has wisely declared this idea impossible: "It is not of course due to Christian influence that the great 'saint of the stake' is taken by the 'king's men,' is crucified (or literally impaled) among thieves, and lives so long that the guard go and tell the king of the miracle."

evidence by this very fact that such influence does not exist.

THE ORIGIN OF KRISHNAISM.

From these details I turn to a question of more general significance, namely the problem of the origin of Krishnaism, of which the oldest continuous source is the Mahâbhârata. What we learn from the great epic with regard to the development of this religion and the connection in which it belongs is briefly as follows:

In the war between the Kauravas and the Pândavas, which forms the kernel of the Mahâbhârata, Krishna, the scion of the Sâivata branch of the Yâdava tribe and the leader of this small nomadic people, stands as friend and helper on the side of the Pândavas. The conjecture that the figure of Krishna is derived from a non-Aryan nation because the name denotes "black" or "dark" and because Krishna is represented in art as a man of a dark blue color,[32] is untenable; for not only the name "Krishna" but also the names of his parents and of his tribe are good Aryan names.

In the oldest portions of the epic Krishna is nothing but a human—yes and all too human—person; for the Pândavas do not destroy their enemies in honorable battle but by cunning and treachery, and it is always Krishna who instigates and defends the treachery. This to be sure may find its explanation in the fact that the Mahâbhârata was originally a poem in honor of the Kauravas which attached to the friend of the Pândavas the stigma of a tricky and deceitful man, and that it was worked over at a later time into a Pândava epic in which of course the ally of its heroes must be glorified. But still it is remarkable that those features of deceit and treachery were not eradicated from the character of Krishna in recasting the

[32] L. D. Barnett, *Bhagavadgîtâ translated*, Introduction, 50; J. Kennedy, JRAS, 1907, 961.

ancient epic; for this proves that at the time when the revision took place Krishna still lived in the memory of the people as a thoroughly human personality.

I will treat later on of the probable motive of the exaltation of Krishna into the sphere of the superhuman, but first I shall give only the facts as far as we have use for them here.

From the leader of a half-savage nomadic tribe Krishna became first a demigod and then the tribal deity of the Yâdavas—a process to which an analogy in modern India may be brought forward in the exaltation of the Marâtha chief Shivaji to divine dignity.[33]

The descendants of the victorious Pândavas were glad to accept the new god who had promoted the advancement of their forefathers and bestowed great care upon the

[33] Hopkins, *India Old and New*, 105, in the essay, "A Study of Gods." In the very same passage Hopkins explains Krishna and Râma to be "originally local chieftains of northern India." His conviction of the originally human nature of Krishna could not be more definitely stated. But farther on in the book where it might be expected, i. e., in the chapter "Christ in India," Hopkins makes no use of this conviction in his treatment of Krishna and Krishnaism. The essay just mentioned, "A Study of Gods," was first published in 1899, and hence was written about the same time as his work *Religions of India* (1898), in which Hopkins on pages 467 and 468 calls Krishna an anthropomorphized god. We are surprised to read this, for a few pages earlier (page 465) Hopkins claims a historical character for Krishna and rightly identifies him "with the character mentioned in the Chândôgya Upanishad, 3, 17, 6," i. e., with a human disciple. It is evident that Hopkins's views with regard to Krishna have changed, and not only in the course of time, but mutually contradictory views are presented at the same time in the same work, yes even within a few pages.

In note 31 I have already mentioned one case in which Hopkins has replaced an earlier correct view at a later time by an incorrect one. Since he does this in silence we must assume that the earlier exposition has escaped his memory to the detriment of the subject in hand. Exactly the same thing may be observed of another passage. In *Religions of India*, page 429, Hopkins says that "the teaching of Christianity certainly may be suspected, but it can not be shown to exist in the Divine Song" (the Bhagavadgîtâ) and on page 430 he declares the Christian influence on this text to be "doubtful to the last degree." Three years later in *India Old and New* (pp. 152 ff.) he expresses himself—without reference to his former view—on the ground of a number of parallels which on closer consideration prove nothing under the circumstances, very decisively *in favor of* the dependence of the Bhagavadgîtâ on the doctrines of Christianity: "They [the parallels] present a body of evidence that is, I think, almost conclusive in favor of one of the religions having borrowed from the other" (p. 155), which according to the context can only mean borrowing from Christianity. Cf. also page 158 where the Fourth Gospel is called "peculiarly suitable to influence the Hindu divines." In this case too the Hopkins of 1898 is to be preferred to the Hopkins of 1901.

worship of the powerful and popular figure. To the Brahmans, who at first could not have approved this god who was avowedly a patron of warriors, and was originally the tribal deity of un-Brahmanized nomads, nothing remained but to make friends with the new cult if they wished to extend their influence to the worshipers of Krishna. They could do nothing better than, by making use of the convenient theory of incarnation, explain Krishna as an incarnation (*avatâra*) of the god Vishnu.[34]

That this occurred at the latest in the fourth century B. C. has been contested, to be sure, by Kennedy;[35] nevertheless it certainly follows from the well-known fact that Megasthenes, who lived as the ambassador of Seleukos Nikator at the court of Pâtaliputra from 302 to 288 B. C., unmistakably recognizes Krishna in his accounts as an avatâra of Vishnu under the name Heracles by the side of Dionysos (= Shiva).[36]

In the later portions of the Mahâbhârata Krishna's exaltation has made greater progress, for there he appears as the All-God, as one with the world-soul, the Brahman.

How genuinely Indian was this entire development we recognize from the fact that it is demonstrated in exactly

[34] Cf. Grierson, ERE, II, 541*b*: "The incorporation was carried out in exactly the same way as that in which we see Brahmaism extending its frontiers at the present day. The process is going on now before our eyes. Local or aboriginal deities are discovered to be identical with Shiva or some other member of the Brahmanical pantheon, and the distinction of caste is conferred upon the converts. Usually they are declared to be Râjputs, or, in other words, of the Kshatriya class. The aboriginal customs and beliefs are at first left untouched, and in a couple of generations no more ardent supporters of the claims of the Brahmanical priesthood are to be found than those who are still fetish-ridden savages."

[35] That his reasons (JRAS, 1907, 962 ff.) prove nothing, has been shown by A. Berriedale Keith (*ibid.*, 1908, 170 ff.). Kennedy's reply to this (505 ff.) has not changed the situation.

[36] Lassen, *Indische Altertumskunde*, II, 2d ed., 1107, 1226. Nârâyana and Vâsudeva (two by-names of Krishna) and Vishnu have already been identified in Taittiriya Aranyake, X, 1, 6; i. e., in a passage which belongs at the latest to the third century B. C. but is probably still older. Cf. Weber, *Ind. Stud.*, XIII, 353, Note 1; A. Berriedale Keith, JRAS, 1908, 171, Note 2. J. Kennedy in JRAS, 1907, 974, places the identification of Krishna and Vishnu not earlier than in the time of Kâlidâsa, that is to say, in the fifth or sixth century *after* Christ!

the same way in a second instance, namely in the hero of the Râmâyana, Râmâ, who originally was also purely human, and who likewise became transformed first into a demigod and finally into the All-God and who like Krishna was regarded as an incarnation of Vishnu. Although the euhemeristic conception has otherwise seldom proved true in the realm of the history of religion, yet in India from earliest antiquity down to the present time, it has often proved to be correct. Not only heroes and founders of sects but also a large number of poets and authors on non-religious subjects have been identified with gods or simply deified in India.[37]

It has therefore never seemed quite intelligible to me that many such scholars as Tiele, Senart, Barth, Kennedy, A. Berriedale Keith—really also A. Weber and Hopkins in the greater part of his utterances—could in spite of the clear evidence of our sources, have described Krishna as originally a purely mythical figure, as a sun-god or a vegetation spirit. Against this conception speak the human character of Krishna in the oldest parts of the Mahâbhârata and the entire development traceable throughout the great epic. Then too the humanization of a primitive deity which these scholars accept in agreement with Indian mythology, would have succeeded too well with the Indian poets to be credible. Krishna is not a humanized god but a deified man, and mythology has reversed the actual relation, as has also been done to be sure in other instances in the transformation myths.

It is easy enough to understand that later when Krishna had become the most popular divinity of the Indian pantheon and his worshipers related more and more wonderful stories about him, all sorts of features entered

[37] H. Jacobi at the close of his paper, "Kultur-, Sprach- und Literarhistorisches aus dem Kautiliya," *Sitzungsberichte der K. Preussischen Akademie der Wissenschaften*, 1911 (XLIV), 973; Hopkins, *Religions of India*, 522, note, after JA, XI, 56, 149.

into his cycle of myths and legends which originally belonged to the ancient sun-god and other deities. The transference of solar myths upon Krishna was a necessary consequence of his identification with Vishnu who was primarily a solar god. Grierson[38] places a rather high value, though without adducing this reason, on the influence of the solar cult, but in other respects takes throughout the standpoint here presented. Moreover, local divinities may also have been entirely fused with Krishna and have been absorbed in him.[39] This seems to be verified by the fact that Dvârakâ, the capital of the mature hero Krishna, is on the west coast of Gujerat, whereas all the legends referring to his childhood and youth are laid in the interior of the country towards Mathurâ on the Yamunâ (near the present Agra) and their vicinity. Of course we may draw no *basis* for an explanation from all such *later additions* to the cycle of Krishna legends.

That of all the heroes of the Mahâbhârata Krishna alone has been exalted in so remarkable a manner is hardly due to an incalculable chance, but must have had a particular cause. In the Mahâbhârata there is no lack of chieftains and successful warriors who would have been equally well or better suited for deification. For the explanation of the distinction of Krishna, R. G. Bhandarker, the most eminent Sanskritist among the natives of India, has proposed a conjecture[40] in whose favor much may be said, and which has later been verified by others with further proofs.[41]

[38] In his important article "Bhaktimârga," ERE, II, 540, *b*.

[39] J. Kennedy, JRAS, 1907, 960 ff., with whose confused mythological speculations, however, I in no wise agree.

[40] In two places consistently: (1) In his *Report on the search for Sanskrit Manuscripts in the Bombay Presidency during the year 1883-84*, Bombay, 1887, p. 74; and (2) In the essay, "The Râmanujiya and the Bhâgarata or Pâncharâtra Systems" in the *Verhandlungen des VII. Internationalen Orientalisten-Kongresses, Arische Sektion*, Vienna, 1888, pp. 101 ff., especially 107 ff. Cf. also G. Bühler, JA, 1894, 248.

[41] Introduction to my translation of the Bhagavadgîtâ, 19 ff.; Grierson,

According to this view Krishna, the son of Vasudeva and Devakî, was not only a tribal chieftain but also the founder of a religion which first gained a footing among the Yâdavas but soon spread beyond the boundaries of the tribal community and became of immense importance in the evolution of religious life in India. This religion is the originally un-Brahmanic *monotheistic religion* independent of Vedic tradition whose adherents were called Bhâgavatas and later Pâñcharâtras and who worshiped the supreme Being under the epithets Bhagavat, "the Exalted One,"[42] and Purusottama, "the supreme spirit." When the founder of this religion was deified in Indian fashion he became identified with the god he had proclaimed; and so Krishna, his patronymic Vâsudeva, "son of Vâsudeva," and Nârâyana, "son of man," came to be other names of this god. The result then of the later Brahmanization of the sect, as we have said before, was that Krishna was also made one form of the god Vishnu.

The Bhâgavata religion from which according to this conception Krishnaism arose, was primarily a popular Kshatriya religion and probably preached the doctrine of divine love from the beginning and emphasized the ethical side to a much stronger degree than Brahmanism, especially the requirement to do one's duty. In proof of this many passages from the Mahâbhârata may be adduced.[43]

The point of departure from the assumption that Krishna was the founder of this religion is furnished by a passage of the old Chândôgya Upanishad (3, 17, 6) in which Krishna, "the son of Devakî," is mentioned as the pupil of a famous sage, the Angirasid Ghora, in connection with doctrines which bear a pronounced ethical character, namely asceticism, liberality, uprightness, doing no one

JRAS, 1908, 603 ff.; "The Nârâyanîya and the Bhâgavatas," IA, 1908, 251 ff., especially 253; "Bhakti-mârga," ERE, II, 539 ff. and elsewhere.

[42] From this is derived *Bhâgavata*, "worshiper of the Bhagavat."

[43] Introduction to my translation of the Bhagavadgîtâ, 24.

harm and speaking the truth (v. 4)—these requirements are to take the place of the sacrificial fee due to the priests, and the sacrifice itself is to be represented in the kind of life to be led.

If we bear in mind at the same time the fact that Krishna is the son of Devakî also in the Mahâbhârata, and appears in its older portions as warrior, councilor, and *promulgator of religious doctrines,* then the identity of the personalities can not be questioned and the character of Krishna as a religious teacher is as well corroborated as can be expected from the nature of the sources. The religion proclaimed by Krishna in the Mahâbhârata is precisely the Bhâgavata religion, and its chief text-book is the Bhagavadgîtâ, the "Song of the Exalted One," (i. e., of Krishna, who is revealed in it as the All-God) the most famous episode of the Mahâbhârata.

The entire conception here submitted gains in probability from the fact that Krishna's patronymic Vâsudeva as the designation of a god, is authenticated by Bhandarkar especially in the tribe to which Krishna, according to all tradition, belongs.

The Chândôgya Upanishad in which Krishna is mentioned dates from pre-Buddhistic times, and since there must surely be a historical basis for the war between the Kauravas and Pândavas, described in the Mahâbhârata, in which Krishna took part, the period of Krishna's life must be set considerably earlier than that of Buddha. Indian mythology places the incarnation of Vishnu as Krishna in the interval between the ages of Dvâpara and Kali, i. e., before the beginning of the present eon.[44] As early as the sixth century before Christ the Krishna cult must have flourished in its fullest bloom, because the ruins of the temple discovered in December, 1896, by Führer at Rummindêi on the southeastern border of Nepal, bear

[44] Lassen, *Indische Altertumskunde,* II, 2d ed., 1128, Note 4.

witness that the ancestors of Buddha worshiped among other objects of their devotion Krishna's favorite wife, Rukminî.[45] The local name Rummindêi is the vernacular corruption of Rukminî devî, "the goddess Rukminî."

At any rate Krishna belonged to an age in which the Kshatriyas had a more important share in the promotion of the spiritual life of India than the Brahmans, who in those centuries squandered their strength mainly in the development of the sacrificial system and in speculations on the significance of the sacrifices, until they were seized by the loftier ideas which proceeded from the Kshatriya caste and were aroused to more worthy manifestation of their abilities. Krishna, the founder of a theistic religion, probably preceded by some centuries the atheistic founders Buddha and Mahâvîra, the originator of the Jaina sect; but all three were Kshatriyas, as were also the founders of the monistic doctrine of the Brahman-Atman, according to the evidence of the older Uponishads.[46]

I was obliged thus far to discuss these preliminary points about Krishna and the origin of Krishnaism in order to be able to approach the most important question in this chapter.

THE CHILD KRISHNA.

That Christian elements entered into the *later* phases of Krishnaism is undeniable and will not be contradicted by any Indologue. This will be further discussed later on. But there is lack of unanimity as to the time from which the Christian influence must be assumed, especially whether it is to be already found in the later parts of the

[45] Karl Eugen Neumann in the introductory preface to A. Paul, *Krischnas Weltengang*, Munich, 1905, 6, 7. When Neumann at the conclusion of this preface says "that all essential and many of the unessential parts of the legend of Krishna are derived from the epoch of the ancient Vedic hymns," a statement is made, without any attempt at proof, which is contradicted by the entire character of the Krishna legend. Not in any case does it extend back to the ancient Vedic period.

[46] See my *Beiträge zur indischen Kulturgeschichte*, Berlin, 1903, 1 ff.

Mahâbhârata serving to glorify Krishna. J. Kennedy, one of the champions in favor of the affirmative, in harmony with earlier expositions of Wilson and Weber, speaks of a complete change in the conception of Krishna.[47] He says that until about 500 A. D. Krishna was a thoroughly warlike god, a destroyer of giants and dragons; but that then his character suddenly and completely changed; that all at once he became an idyllic pastoral god, a child growing up to young manhood and also a god of love; that the Krishna *child* especially threw the older Krishna and other deities in the shade and everywhere made victorious headway. This last observation is correct and verifies a fact whose significance for the history of religion is greatly underestimated by Oldenberg when he asks[48] what ultimate significance the idyll of the Krishna child has for Hinduism. In a later essay[49] Kennedy explains this alleged sudden change by the assumption that about that time Scythian (i. e., Central Asiatic) nomads brought the "child-god" from the north to Mathurâ and with him a Christian legend and a Christian festival.

This entire theory fails under critical investigation. The sudden change in the conception of Krishna was really a very gradual transformation the beginnings of which take us back to a very much earlier time than Kennedy supposes. Since this scholar places particular weight upon the significance of Krishna as a child, I will first take up this point in detail.

The earliest connected narrative of Krishna's birth and childhood[50] is to be found in the Harivamsha, "the genealogy of Hari, i. e., of Vishnu," an appendix to the

[47] JRAS, 1907, 486.

[48] *Indien und die Religionswissenschaft*, 20.

[49] "The child Krishna, Christianity, and the Gujars," JRAS, 1907, 951-992, especially 976, 981 ff., 989. Similarly also Hopkins in *India Old and New*, 162.

[50] Two subordinate features are briefly mentioned in Mbh., II, 1439, 40, in a passage acknowledged to be a late interpolation.

Mahâbhârata which as early as the fifth century A. D. was considered a component part of the great epic[51] and can not have been written essentially earlier. The Harivamsha in its second part—which is the greatest and most important of its three divisions—treats of Vishnu incarnated as Krishna, but not of the ally of the Pândavas and the promulgator of religious doctrines as does the Mahâbhârata proper; rather does it offer a legendary biography of Krishna from his birth together with all the heroic deeds, adventures and love stories which we find also in the later Purana literature. Especially the fifth book of the Vishnupurâna[52] and the tenth of the Bhâgavatapurâna which indeed is much more extensive, agree pretty well in substance with the Krishna part (Vishnuparvan) of the Harivamsha.

I shall give only the beginning of this biography of Krishna, which has special importance for us, as told in Winternitz's summary,[53] and sum up the rest in a few words.

"In the city of Mathurâ there reigned a wicked king Kamsa. Nârada told him that he would meet death at the hands of the eighth son of Devakî, the sister of his father and the wife of Vasudeva. Thereupon Kamsa determined to slay all the children of Devakî. He had his servants keep a strict watch on Devakî, and six of her children were put to death as soon as they were born. The seventh child—who was that brother of Krishna later known as "Râma with the ploughshare," "Balarâma" or "Baladeva"—was rescued by Nidrâ, the goddess of sleep, who took the child from his mother before his birth and transferred him to Rohinî, another of Vasudeva's wives. But the eighth son,

[51] Winternitz, *Geschichte der indischen Litteratur*, I, 395.

[52] Translated into German by A. Paul, *Krischnas Weltengang*, Munich, 1905.

[53] *Op. cit.*, I, 381.

who was Krishna, Vasudeva himself, in order to save him from Kamsa, exchanged as soon as he was born for the daughter who had been born at the same time to the shepherd folk, Nanda and Yashodâ. So the shepherd's daughter was hurled against a rock by Kamsa while Krishna was thought to be the son of a shepherd and grew up among the herdsmen. To the guardianship of the herdsman's family, Vasudeva entrusted Râma also, and the two boys grew up together as herdsmen."

While yet an infant Krishna gave evidence of his superhuman power, and when a boy performed miraculous and heroic deeds which caused him to be considered the special guardian of pastoral life. For instance he overcame a terrible snake-demon in the Yamunâ and compelled him with all his train to withdraw into the ocean; and during a frightful storm he held a mountain as a protection over the shepherds and their flocks for seven days so that they remained uninjured. Although the shepherds wished because of these deeds to worship him as a god, he preferred to pursue his life among them simply as their friend and kinsman. Now for the first time are described his nocturnal revels, frolics and dances with the shepherd girls who are all in love with him and sing of his heroic deeds.

Of all these deeds in which Krishna overcomes a vast number of men and demons and once even the god of death in the lower world, we need mention here only one, the revenge he took on his wicked uncle Kamsa. In his residence at Mathurâ, this king heard of the deeds of valor of the two young herdsmen Krishna and Râma, and because he was afraid of them he concluded to put them out of the way by strategy. He invited them to his capital to a festival and a contest with two of his strongest wrestlers. The two young heroes came and killed the powerful wrestlers, and when King Kamsa in his wrath commanded the victors to be driven from the country, Krishna laid hold of

the king, drew him on to the place of combat and killed him.

In the beginning of this legendary biography of Krishna, Kennedy sees, as others have seen before him, an imitation of Christian prototypes. The slaughter of Vasudeva's children is thought to have been copied from the slaughter of the innocents at Bethlehem, and the early life of Krishna in a shepherd community from the birth of Christ among the shepherds. The agreements in the two parallels are certainly not so remarkable as to make at first sight the dependence of these features of the Krishna legend upon the New Testament narratives very probable. Still in this case we do not need to establish our position upon such general considerations but are so fortunate as to be able to prove positively the incorrectness of the loan hypothesis.

In Patañjali's Mahâbhâshya, the great commentary on the grammar of Panini which was written in the middle of the second century B. C., we find several examples of Krishna's hostile relation to his uncle Kamsa: "Krishna was hostile to his uncle" (2, 3, 36), "Vâsudeva, as everybody knows, slew Kamsa" (3, 2, 111), and in 3, 1, 26, the *Kamsavadha,* "the slaying of Kamsa," and the *Balibandha,* "the capture of the demon Bali," that is to say, two well-known acts of Krishna, or Vishnu, are mentioned as familiar material for rhapsodies, dramatic presentations and paintings.[54] That enmity existed between Krishna and his uncle Kamsa and that the latter had met his death at the hands of his nephew, were accordingly features of the Krishna legend knowledge of which could be assumed to be general at the time of the Mahâbhâshya. This requires a further line of argument. The features of the legend we have given represent at any rate such a remarkable di-

[54] A. Weber, *Ind. Stud.*, 13, 353 ff., 488 ff.; A. Berriedale Keith, JRAS, 1908, 172 ff.

vergence from the usual state of things between near relatives, that where a story was in circulation in which the nephew is the foe of his uncle and slays him, the cause of this abnormal relation must also have been a part of the story. Whoever was acquainted with these features must also have been familiar with the attempts of the uncle to put out of the way the nephew whom he feared. Whence it follows that at the time of the Mahâbhâshya those circumstances too were already generally known which according to the narrative of the Harivamsha had taken place before, at and after the birth of Krishna, and that especially the story of the slaughter of Vasudeva's children is older than the story of the slaughter of the innocents at Bethlehem.

Accordingly in the second century before Christ, not only the powerful hero Krishna, but even the Krishna child already played a significant rôle in Brahman India, and indeed the *divine child* since (as we have seen above, pages 338 and 342) Krishna had been worshiped as God as early as the sixth century B. C. in Buddha's native land,[55] and his identification with Vishnu was established by the fourth century B. C.

The divine child Krishna accordingly does not appear in India suddenly about 500 A. D. as Kennedy tells us, but was known there at least 700 years earlier, and indeed in his particular relation to pastoral life. Therefore his veneration is of genuinely Indian origin.

Hence it would not be necessary to examine critically Kennedy's assumption that it was the Gujars (Sanskrit, *Gurjara*) who brought the worship of the Christchild from Central Asia to Mathurâ about 500 A. D. But the absolute untenability of the theory just refuted becomes even

[55] The Brahmanic Hindus who emigrated to the western part of further India in the second century A. D. were also worshipers of Vâsudeva; and the same is to be assumed of those who settled on the island Madura near Java. Lassen, *Indische Altertumskunde*, II, 2d ed., 1112.

clearer when we recognize that the speculations upon which Kennedy found his standpoint hang entirely in midair. We are not clear either with regard to the ethnological position nor the original home of the Gujars, who first appear in the northwest part of the Punjab in the middle of the sixth century A. D. and later extend farther south especially over the peninsula named for them Gujarât. Nor have we any account that the Gujars—and indeed as early as about 500 A. D.—reached the region of Mathurâ; nothing that we know about them speaks in favor of this. But before all else we shall ask whether the Gujars were Christians or were so imbued with Christian conceptions that we may assume that through their influence the Krishna legend was transformed in the Christian meaning. And would the Brahmanic Indians in Mathurâ, who belonged to a much higher grade of civilization, have been very ready to accept instruction from a crude race of immigrant nomads? As an answer to the first question we find Kennedy[56] suggesting the hypothesis that the Gujars "*might have* acquired some tincture of Christianity, either from their neighbors in Central Asia or from their connection with Christians among the Hûnas." For the Gujars are mentioned in connection with the Huns and probably penetrated into India together with them.[57] Somewhat farther down Kennedy says (p. 990): "Probably the nomads who brought the new god to Mathurâ knew little of Christianity except the stories of the Infancy." Hence men who knew so little of Christianity, and possibly not even that, who according to Kennedy at best—"might have" shows how insecure Kennedy feels the basis of his reasoning to be—had come only into the most external contact with Christianity, are supposed to have had sufficient interest in it to carry the doctrine of the Christchild to other nations!

[56] JRAS, 1907, 989.

[57] Hoernle and Stark, *History of India*, 61.

To spread religious teachings among foreign people and those of another faith usually requires a zeal enkindled by the strongest conviction.

But enough! It may be maintained with absolute certainty that Christianity, the Gujars, and the date 500 A. D. have nothing to do with the appearance of the Krishnachild in the religious life of India. The appearance of Christian features in the legends of Krishna's birth and childhood and in the Krishna cult did not take place at the earliest until two centuries later and must be placed to the account of the Nestorian missions.

As with the beginning of the Krishna legend the case is the same with another of its features which is referred by Hopkins to a Christian prototype in a way entirely incomprehensible to me.[58] I refer to the flirtations of Krishna with the shepherdesses in which Hopkins sees a reflection of "eternal Christianity" which he declares to be as "palpable" as it is "shocking." What in Christianity is meant spiritually is, according to Hopkins, interpreted in India physically and carnally. "The love of the Bridegroom is sensual; the brides of God are drunken dancing girls."

The truth is we have the same development on both sides. Sensual love which is celebrated in the Old Testament marriage songs of Canticles is raised to a spiritual sense by Christian symbolism when it is made to represent the longing of the human soul for the Saviour under the image of the bridal relation. In like manner in India the much celebrated love of the shepherdesses for Krishna later became spiritualized and was given a new meaning in the sense of the ardent love of man for the deity.

It would be too strange for a legend relating the life of Krishna among the shepherds to have contained nothing of the love and admiration felt by the rustic maidens for the hero and of his love affairs with them; for in the

[58] *Religions of India*, 430.

popular view all heroes of extraordinary strength are inexhaustible in the enjoyment of love, and in spite of all renunciation of the world and asceticism, the erotic element plays a much larger part in the life of the highly sensually organized Hindus than in the Occident. Therefore this feature of the Krishna legend has not originated by the adoption and degradation of a Christian idea, but it is genuinely Indian and is precisely demanded by the situation; moreover it is older then the entrance of Christian influences into Brahman India. For even though Krishna's flirtations are treated in poetic form for the first time in the Harivamsha[59] yet their conception dates from a much earlier time. As early as in the Mahâbhârata (2,2291) Krishna is addressed by Draupadî as the "lover of the shepherdesses" (*Gopîjanapriya*) in a passage belonging to one of the older portions of the great epic, where there can be no question of the possibility of a Christian influence which in the opinion of Hopkins is supposed to be "obvious."

There now remain for our consideration only two more features of Krishnaism which are found as early as in the Mahâbhârata and whose derivation from Christianity has been not infrequently asserted or surmised. These are the conception of Krishna as the god who loves mankind and the requirement to render to Krishna a believing love. These two features appear most distinctly in the Bhagavadgîtâ, the most splendid portion of the Mahâbhârata, and they have found there their most significant expression. Since the Bhagavadgîtâ on account of its unique position in India which has been maintained down to the present day, and on account of its many parallels with the New Testament, requires a separate investigation, the divine love which this song celebrates in its twofold sense

[59] This is done later most extensively in the tenth book of Bhâgavatapurâna, and in an esthetically complete fashion in Jayadeva's *Gitagovinda.*

will best be treated in an article on the Bhagavadgîtâ. But even here it is well to point out that for reasons which will then be duly considered the assumption of Christian influence upon the Bhagavadgîtâ is impossible. Therefore I come back to what I have said in the beginning, that the fantastic account of Shvetadvîpa in the twelfth book of the Mahâbhârata must be characterized as the only portion of the epic in which a remote echo of Christianity is to be found with any degree of certainty.

RICHARD GARBE.

TÜBINGEN, GERMANY.

ROBERT HOOKE AS A PRECURSOR OF NEWTON.

MACH[1] has emphasized that in estimating the achievements of Newton in the theory of gravitation we should not underrate that of the imagination. "We have, indeed," says Mach, "no hesitation in saying that this last is the most important of all." In the present article, I wish to point out the fact that the way for this feat of imagination was amply prepared, notably by Robert Hooke, whose works can hardly have been quite unknown—directly or indirectly— to Newton.

The ideas that the key to the motions of the sun and planets was a gravitational force and that the orbits could be explained by a force deflecting the planets from the straight line which, according to Galileo's law of inertia, they would otherwise describe uniformly, were quite familiar to Newton's elder contemporaries Wren, Hooke and Halley. What made it impossible for them, and possible for Newton, to unlock the door which guarded one of the secrets of the heavens was simply due to the happy circumstances that Newton was a great and far-seeing mathematician, and the time was ripe for the reduction of infinitesimal ideas into a powerful method. The "method of fluxions" was, we know, discovered by Newton even before the falling apple, according to the well-known story, first turned his thoughts toward gravitation.

Newton's feat of imagination consisted[2] in the widen-

[1] *Mechanics*, p. 189.
[2] *Ibid.*, p. 190.

ing of his sphere of thought so as to connect the falling of the moon in her orbit towards the earth with the descent of a stone near the surface of the earth. Newton[3] himself illustrated the identity of terrestrial gravity with the universal gravitation which determines the motions of the celestial bodies by imagining stones to be projected from the top of a high mountain with greater and greater horizontal velocities. Finally the stones become satellites circulating round the earth. Later, commenting on Rosenberger's[4] statement that the idea of universal gravitation did not originate with Newton, Mach[5] says: "But it may be safely asserted that it was with all of them a question of conjecture, of a groping and imperfect grasp of the problem, and that no one before Newton grappled with the notion so comprehensively and energetically; so that above and beyond the great mathematical problem, which Rosenberger concedes, there still remains to Newton the credit of a colossal feat of the imagination." Mach[6] then gave a short account of some of Hooke's researches, and concluded: "Thus Hooke really approached nearest to Newton's conception, though he never completely reached the latter's altitude of view."

It seems to me that we must lay less stress on Newton's feat of imagination and more stress on his great advance in mathematics and its applications to physics than Mach, apparently, would admit. Further, and this seems to me the most important thing from a philosophical point of view, we shall see that Hooke had begun to grasp that principle of mechanics which Newton grasped more firmly in his third "Law of Motion."

In quotations from old works, I shall, since my object

[3] *Ibid.*, pp. 533-534.

[4] *Isaac Newton und seine physikalischen Principien*, Leipsic, 1895, pp. 135-157.

[5] *Mechanics*, p. 531.

[6] *Ibid.*, p. 532.

is scientific and not merely literary, modernize spelling and punctuation. However I shall always quote literally for purposes of reference the *titles* of books and such passages as seem to have a literary interest.

I.

Robert Hooke was born at Freshwater in the Isle of Wight on July 18, 1635. He was very infirm and weakly and was therefore nursed at home, though his brothers and sisters were nursed abroad, and for at least seven years his parents had very little hope of his life, since he was often ill. For his age he was very sprightly and active in running, leaping, and so on, though very weak as to any robust exercise. He was very quick to learn anything, and, after his English, soon learned his Grammar by heart but, as he says, with little understanding, till his father, who was minister of the parish of Freshwater, designing him for the ministry, took some pains to instruct him. But since he was very often subject to the headaches which hindered his learning, his father laid aside all thoughts of breeding him a scholar, and finding that he himself grew very infirm through age and sickness, he wholly neglected his son's further education. Thus Hooke being left to himself spent his time in making little mechanical toys about which he was very intent. He endeavored to imitate everything he saw done by any mechanic; he had also a great fancy for drawing. How he spent the next six or seven years of his life is not known. After his father's death in 1648, he was placed in the workshop of Sir Peter Lely the painter, but presumably stayed there only a short time as the smell of the oil colors did not agree with his constitution. After this he lived with Dr. Busby, master of Westminster School, with whom his education progressed with surprising rapidity both in its classical and mathematical branches. Here he applied himself to Latin

and Greek and at the same time made some acquaintance with Hebrew and other Oriental languages. Here too he began a serious study of mathematics. From Westminster School he went in 1653 to Christ Church, Oxford, as "servitor" (one who performed certain menial duties instead of paying fees) and ten years later he took his M.A. degree by special recommendation of Lord Clarendon, then Chancellor of the university. After 1655 he was employed and patronized by the famous experimental physicist (the Hon.) Robert Boyle,[7] who turned Hooke's skill to account in the construction of his celebrated air-pump. Hooke's inventive faculty exercised itself between 1657 and 1659 in devising thirty different methods of flying, and also—more profitably—in regulating the movements of watches by the application of the balance spring. In 1675 a lively controversy arose between him and Huygens respecting their rival claims to this ingenious invention. The truth seems to be that the original idea belonged to Hooke, but that the coiled form of the spring, on which its practical utility depends, was due to Huygens. On November 12, 1662, Hooke was appointed first curator of Experiments to the Royal Society,[8] and filled the office with extraordinary diligence and skill during the remainder of his life. In 1664 Sir John Cutler instituted for Hooke's benefit a mechanical lectureship of £50 a year, and in the following year he was nominated Professor of Geometry in Gresham College, London, where he subsequently resided. After the great fire in 1666 he constructed a model for the rebuilding of the city, which was highly approved although the design of Wren was preferred. Neither plan was, however, adopted. During the progress of the works Hooke acted as surveyor, and accumulated in that lucrative employment a sum of several thousand pounds. This hoard was dis-

[7] See Mach, *Mechanics*, pp. 123-127.

[8] This society was founded in 1662. Cf. Rosenberger, *op. cit.*, pp. 69-71.

covered after his death in an old iron chest which had evidently lain unopened for about thirty years. He fulfilled the duties of secretary to the Royal Society during five years after the death of Henry Oldenburg in 1677.

A protracted controversy with Hevelius, in which Hooke urged the advantages of telescopic over plain sights, brought him little but discredit. His reasons were good but his offensive style of argument rendered them unpalatable and himself unpopular. Many circumstances concurred to embitter the latter years of his life. The death in 1687 of his niece, Mrs. Grace Hooke, who had lived with him for many years, caused him deep affliction; a lawsuit with Sir John Cutler about his salary—a suit which was, however, decided in his favor in 1696—occasioned him prolonged anxiety; and the repeated anticipation of his discoveries inspired him with a morbid jealousy. Marks of public respect were not wanting to him. A degree of M.D. was conferred on him at Doctor's Commons, December 7, 1691, and in 1696 the Royal Society made him a grant to enable him to complete his scientific inventions. While engaged on this task he died, worn out with disease and toil, on March 3, 1703, and was buried in St. Helen's Church, Bishopsgate Street.

In personal appearance Hooke made but a poor show. His figure was crooked and his limbs shrunken; his hair hung in disheveled locks over his haggard countenance. His temper was irritable, his habits penurious and solitary. He was blameless in morals, and reverent in religion. His scientific performances would probably have been more striking if they had been less varied. He originated much, but perfected little. His optical investigations led him to adopt in an imperfect form the undulatory theory of light, to anticipate the doctrine of interference, and to observe independently of, though subsequently to, Grimaldi the phenomenon of diffraction. He was the first to state clearly

that the motion of heavenly bodies must be regarded as a mechanical problem, and he approached in a remarkable manner the discovery of universal gravitation. He suggested a method of meteorological forecasting and a system of telescopic signaling, anticipated Chladni's experiment of strewing a vibrating bell with flour, investigated the nature of sounds and the function of the air in respiration and combustion, and originated the idea of using the pendulum as a measure of gravity.[9]

His principal writings are *Micrographia or some Physiological Descriptions of Minute Bodies* (London, 1665, 1667),[10] *Lectiones Cutlerianae* (London, 1679), and *Posthumous Works*, containing a sketch of his "Philosophical Algebra," published by Richard Waller in 1705. A biography of Hooke was prefixed by Waller to the *Posthumous Works of Robert Hooke.*[11] This prefixture, entitled "The Life of Dr. Robert Hooke,"[12] which, by the way, has been referred to by Brewster[13] as if it were a separate publication and which utilized the beginning of an autobiography left by Hooke, gave, in Waller's words, "An Account of his Studies and Employments, with an Enumeration of the many Experiments, Instruments, Contrivances and Inventions, by him made and produced as Curator of Experiments to the *Royal Society.*" This biography, together with that in the ninth edition of the *Encyclopaedia Britannica,* has been used in what precedes.

Hooke was a very ingenious man and a skilful experimenter. Here we are only concerned with his speculations

[9] Cf. also W. W. Rouse Ball, *A Short Account of the History of Mathematics,* 4th. ed., London, 1908, p. 315. Cf. also Rosenberger, *op. cit.* pp. 71-73.

[10] Rosenberger, *op. cit.,* p. 35.

[11] *The Posthumous Works of Robert Hooke,.. Containing his Cutlerian Lectures and other Discourses Read at the Meetings of the Illustrious Royal Society. In which....,* published by Richard Waller, London, 1705.

[12] *Ibid.,* pp. i-xxviii.

[13] *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton,* Edinburgh, 1855, Vol. I, pp. 285, 286; 2d. ed., 1860, Vol. I, p. 249.

on gravitation and his relations with Newton on this point. The biographical details into which we have entered are very much to the point when we are considering Hooke's work on the theory of gravitation. Hooke's education, owing to his health and worldly circumstances, was incomplete. Owing to these reasons and his ill fortune with his inventions and writings, he was jealous and embittered. His speculations show that he was, I think, quite the equal of Newton in imagination. As a mathematician he was vastly inferior to Newton, and hence his merits have been less noticed than they deserve to be, since they lie in the shadow of the great theory which was almost completed by Newton with unrivaled mathematical talent. And lastly, Newton himself seems to have underestimated the value of Hooke's work and perhaps even its influence on himself. Both in his researches on the theory of gravitation and in his discovery of the method of fluxions, Newton showed at first an almost complete lack of interest in his rights of authorship, and later, when a question of whether others had plagiarized from him arose, he showed himself touchy, suspicious, ready to attribute meannesses to others, and ready to expend great labor in the carrying out of a mean action. An example of this last unenviable characteristic is given by the discovery, after Newton's death, of a first draft in Newton's own handwriting of an account—in Newton's favor—of the dispute between Newton and Leibniz and their supporters about the invention of the infinitesimal calculus. This document was intended to appear as, and was indeed printed as, the unbiassed report of a committee of independent judges appointed by the Royal Society.

Newton's amanuensis has left on record how Newton, with apparent carelessness, used to leave a box of guineas lying about in his rooms at Trinity College, Cambridge. The amanuensis thinks it possible that this was done to

test the honesty of the old woman who made his bed and cleaned his rooms. It is difficult not to be forced to think that we see some analogy between his scientific and his domestic methods. If we resist this temptation, we shall have to assume that in early life Newton was either not conscious of the importance for science of his discoveries or even did not esteem science itself very highly, but that in later life his sense of property grew so strong that it embraced even things for which he did not care. I do not think that it can be maintained that Newton, at any rate until he was old, did not really esteem science highly. He wrote[14] indeed to Hooke in 1678 that he "had for some years past been endeavoring to bend" himself "from philosophy to other studies in so much," said he, "that I have long grudged the time spent in that study unless it be perhaps at idle hours sometimes for a diversion," and[15] that his "affection for philosophy" was "worn out, so that," as he said, "I am almost as little concerned about it as one tradesman uses to be about another man's trade or a country man about learning"; and[16] to Halley in 1686 that "Philosophy is such an impertinently litigious Lady that a man had as good be engaged in lawsuits as have to do with her. I found it so formerly, and now I am no sooner come near her again, but she gives me warning." Still, Newton fortunately did not then abandon "philosophy." He hated and was irritated by controversy, but in spite of this he only abandoned the science which gave rise to the controversies he suffered so impatiently when he was honored and prosperous and when nobody in England had the presumption to set up an opinion against that of the great and god-like Newton.

Nor could Newton have been under the delusion that

[14] W. W. Rouse Ball, *An Essay on Newton's Principia,* London, 1893, p. 141; cf. pp. 155, 157.

[15] *Ibid.,* p. 44.

[16] *Ibid.,* pp. 158-159.

his discoveries were of little moment to science. So we must, I think, infer that his character changed from the frankness shown in his first printed researches on optics[17] to the secretiveness and grudgingness to others shown in the manner in which the *Principia* was written, and in the jealousy, lack of candor and suspicion shown to all but his most intimate friends. This change was brought about, it seems, by the partly irritating controversies—the criticisms and objections of Hooke, Huygens, Pardies, Linus, Gascoigne, Lucas[18]—to which his early optical researches gave rise.

We will now turn to Hooke's publications. It seems true that, as Rosenberger[19] says: "Since Hooke, like Borelli, was a very clever physicist but no mathematician, he too could only be the percursor of a greater discoverer in whose brightness the lesser sun of his fame faded from view more than it should."

II.

As an indirect result of an inquiry into the nature of gravity instituted by the Royal Society in 1661,[20] Hooke on March 21, 1666, according to Birch,[21] "presented a paper, which was read, containing some experiments of gravity made in a deep well near Banstead Downs in Surrey; to which was annexed the scheme of an instrument for finding the difference of the weight, if any, between a body placed on the surface of the earth, or at a considerable

[17] Cf. Rosenberger, *op. cit.*, pp. 67-68.

[18] *Ibid.*, pp. 73-117.

[19] *Ibid.*, pp. 150-151.

[20] *Ibid.*, p. 151.

[21] Thomas Birch: *The History of the Royal Society of London for improving of Natural Knowledge, from its first rise. In which the most considerable of those Papers communicated to the Society which have hitherto not been published, are inserted in their proper order, as a Supplement to the Philosophical Transactions*, Vol. II, London, 1756, pp. 69-72; the extract is from pp. 69-70. Cf. pp. 77-78.

distance from it, either upwards or downwards. It was ordered that this paper should be registered[22] as follows:

" 'Gravity, though it seems to be one of the most universal active principles in the world, and consequently ought to be the most considerable, yet has it had the ill fate to have been always, till of late, esteemed otherwise, even to slighting and neglect. But the inquisitiveness of this later age has begun to find sufficient arguments to entertain other thoughts of it. Gilbert began to imagine it a magnetical attractive power inherent in the parts of the terrestrial globe; the noble Verulam [Francis Bacon] also, in part, embraced this opinion; and Kepler (not without good reason) makes it a property inherent in all celestial bodies,—sun, stars, planets. This supposition we may afterwards more particularly examine; but first it will be requisite to consider whether this gravitating or attracting power be inherent in the parts of the earth, and, if so, whether it be magnetical, electrical, or of some other nature distinct from either.

" 'First then, if it be magnetical, any body attracted by it ought to gravitate more, when nearer to its surface, than when farther off.' "

The ingenious experiments, which were conducted at the tops of Westminster Abbey and St. Paul's Cathedral, led, however, to no result.[23]

III.

On May 23, 1666, according to the Journal Book of the Royal Society,[24] there was read "a paper of Mr. Hooke's concerning the inflection of a direct motion into a curve by a supervening attractive principle," which was ordered

[22] Register, Vol. III, p. 93.

[23] Rosenberger, *op. cit.*, pp. 151-152; Mach, *Mechanics*, p. 532.

[24] Waller, *loc. cit.*, p. xii; Birch, *op. cit.*, pp. 90-92; Rouse Ball, *Essay*, p. 151.

to be registered.[25] "The discourse contained therein," says Waller, quoting Hooke, "is an introduction to an experiment to show that circular motion is compounded of an endeavor by a direct motion by the tangent and of another endeavor tending to the center."

This paper is as follows:[26]

"I have often wondered why the planets should move about the sun according to Copernicus's supposition, being not included in any solid orbs (which the ancients possibly for this reason might embrace) nor tied to it, as their center, by any visible strings; and neither depart from it beyond such a degree, nor yet move in a straight line as all bodies that have but one single impulse ought to do. For a solid body, moved in a fluid towards any part—unless it be protruded aside by some near impulse, or be impeded in that motion by some other obviating body, or that the medium through which it is moved be supposed not equally penetrable every way—must persevere in its motion in a right line, and neither deflect this way nor that way from it. But all celestial bodies, being regular solid bodies, and moved in a fluid and yet moved in circular or elliptical lines and not straight, must have some other cause besides the first impressed impulse that must bend their motion into that curve. And for the performance of this effect I cannot imagine any other likely cause besides these two: The first may be from an unequal density of the medium through which the planetary body is to be moved. That is, if we suppose that part of the medium which is farthest from the center, or sun, to be more dense outward than that which is more near, it will follow that the direct motion will be always deflected inwards by the easiest yielding of the inward and the greater resistance of the outward part of that medium. This has some probabilities attend-

[25] Register, Vol. III, p. 114.

[26] Birch, *op. cit.*, pp. 90-91.

ing it: thus, that if the ether be somewhat of the nature of the air, it is rational that that part which is nearer the sun, the fountain of heat, should be most rarified, and consequently that those which are most remote should be most dense; but there are other improbabilities that attend this supposition which, being nothing to my present purpose, I shall omit.

" 'But the second cause of inflecting a direct motion into a curve may be from an attractive property of the body placed in the center whereby it continually endeavors to attract or draw it to itself. For if such a principle be supposed, all the phenomena of the planets seem possible to be explained by the common principle of mechanical motions, and possibly the prosecuting this speculation may give us a true hypothesis of their motion, and from some few observations their motions may be so far brought to a certainty that we may be able to calculate them to the greatest exactness and certainty that can be desired.' "

Hooke illustrated the motions of the planets about the sun by means of an experiment with a conical pendulum.[27] The force to the center, in this case, increases with the distance, which is not so with the attraction of the sun. The experiment was thus merely superficially imitative and not explanatory, and the most interesting thing was a second pendulum-experiment which imitated the motion of the moon. Hooke added a smaller ball which he made to swing round the first by means of a short string that was fastened to the wire; he then remarked "that neither the bigger ball which represented the earth nor the less which represented the moon were moved in so perfect a circle or ellipsis as that in which they would otherwise have moved if either of them had been suspended and moved singly,

[27] Cf. Waller, *loc. cit.*, p. xii; Birch, *op. cit.*, pp. 91-92; Brewster, *op. cit.*, Vol. I, pp. 283-286; 2d ed., pp. 247-249; Rosenberger, *op. cit.*, pp. 152-153; S. P. Rigaud, *Historical Essay on the first Publication of Sir Isaac Newton's Principia*, Oxford, 1838, pp. 38-40.

but that a certain point, which seemed to be the center of gravity of these two bodies, however posited[28] (considered as one), seemed to be regularly moved in such a circle or ellipsis, the two balls having other peculiar motions in small epicycles about the same point."

"This last observation reminds us," says Rigaud, "of the fundamental property of motion in the eleventh section of the first book of the *Principia*; but that was much more than Hooke could have demonstrated, and indeed his experiment, though it answered the immediate purpose of illustrating his hypothesis, admitted no further reasoning to be derived from it as to the motion of the planets. He was aware that it did not represent the true action of gravitation, because the tendency towards the middle (there was no fixed point to which the body was constantly drawn) increased with the horizontal distance, which he knew to be wrong, although he gave no indication at the time of his knowing what the law really was by which the variation of gravity was regulated."

The eleventh section of the first book of the *Principia* is on the motions of bodies under their mutual attractions, and here, for the first time in the *Principia,* is applied the third law of motion—or rather that (fourth) corollary from it known as the principle of the conservation of the center of gravity. Hooke's name is not mentioned in connection with the third law in Newton's scholium, but here and, as we shall see, elsewhere, Hooke made quite perceptible advances towards both this law and the Newtonian conception of "mass." In neither case did he bring his thoughts into the form of a definite enunciation, but he may, I think, be considered as occupying in this respect a position intermediate between Descartes and Newton.

The instinctive nature of the third law may also be illus-

[28] Brewster has here the misprint "pointed."

trated by an extract from Birch's *History*[29] which immediately follows the account of Hooke's paper just referred to:

"Mr. Oldenburg produced a letter written to him by Dr. Wallis from Oxford, May 19, 1666,[30] in answer to the objections made at the preceding meeting against his hypothesis of the tides. This letter giving occasion to renew the discourse upon that subject, Dr. Goddard offered to the consideration of the Society this doubt, viz., supposing the earth and moon to move about a compound center of gravity, if the highest tides be at new moon when the earth is farthest from, and the moon nearest to the sun, and the tides abate as the earth approaches nearer till she comes into the supposed circle of her annual motion; why they do not abate, as the earth comes still nearer to the sun within the said circle? And so why we have not one spring-tide and one neap-tide in every course of the moon?"

Let us return to Hooke's idea—an idea which is a consequence of Galileo's considerations and was shared by Wren and Halley[31]—of compounding the planetary motions of a direct tangential motion and an attractive motion towards the central body. Hooke in a letter to Newton of 1679[32] asked for Newton's thoughts on this idea. Newton in his answer said[33] that so far as he remembered he had not before heard of this "hypothesis." Hooke, judging from his manuscript comments on this letter,[34] did not believe this statement. There seems no reason to doubt Newton's word; we know that such ideas were not peculiar to Hooke alone, and further, building on the dynamics of

[29] Vol. II, p. 93.

[30] Letter-Book, Vol. I, p. 320: It is printed in the *Phil. Trans.*, No. 16, pp. 281-283, end of the 2d section.

[31] Rouse Ball, *Essay*, p. 162.

[32] *Ibid.*, p. 140.

[33] *Ibid.*, p. 141.

[34] *Ibid.*, pp. 144-145, 152.

Galileo, Newton was surely quite capable of extricating and applying such an idea.

IV.

In March, 1671,[35] Hooke "showed several experiments to explain the nature and cause of gravity: particularly, on the 9th, an experiment was made in which some flour put into a void shallow glass with a large sloping brim and a pretty tall foot was made to rise and run over like a fluid, by the knocking on the edge of the glass, and also by the forcibly moving of one's finger round the edge of the same. Leaden bullets also being put into this glass, did, by knocking, move it like a fluid. . . . This was proposed to consider what might be the cause of gravity and suggest an hypothesis to explicate the motion of gravity by. . . ."

V.

Later Hooke resumed the consideration of the subject of the planetary motions, and in a work which appeared in 1674[36] he published some interesting observations on gravity. "I shall hereafter," he says,[37] "explain a system of the world, differing in many particulars from any yet known but answering in all things to the common rules of mechanical motions. This depends upon three suppositions. First, that all celestial bodies whatsoever have an attraction or gravitating power towards their own centers whereby they attract not only their own parts and keep them from flying from them, as we may observe the earth to do, but that they also do attract all the other celestial bodies that are within the sphere of their activity; and consequently that not only the sun and moon have an in-

[35] Waller, *loc. cit.*, pp. xiv-xv.

[36] *An attempt to prove the Annual Motion of the Earth, from Observations made by Robert Hooke,* London, 1674; Cf.. *Phil. Trans.*, No. 101, p. 12. Cf. also Brewster, *op. cit.*, Vol. I, pp. 286-288, 2d ed., Vol. I, pp. 249-251; Rosenberger, *op. cit.*, pp. 153-155; Rouse Ball, *Essay*, pp. 151-152.

[37] At the end, pp. 27-28.

fluence upon the body and motion of the earth, and the earth upon them, but that Mercury and also Venus, Mars, Jupiter, and Saturn, by their attractive powers, have a considerable influence upon its motion, as in the same manner the corresponding attractive power of the earth has a considerable influence upon every one of their motions also. The second supposition is this, that all bodies whatsoever that are put into a direct and simple motion will so continue to move forward in a straight line till they are, by some other effectual powers, deflected and bent into a motion describing a circle, ellipsis, or some other more compounded curve line. The third supposition is that these attractive powers are so much the more powerful in operating, by how much the nearer the body wrought upon is to their own centers. Now what these several degrees are I have not yet experimentally verified; but it is a notion which, if fully prosecuted as it ought to be, will mightily assist the astronomer to reduce all the celestial motions to a certain rule, which I doubt will never be done true without it. He that understands the nature of the circular pendulum and of circular motion will easily understand the whole ground of this principle, and will know where to find direction in nature for the true stating thereof. This I only hint at present to such as have ability and opportunity of prosecuting this inquiry and are not wanting of industry for observing and calculating, wishing heartily such may be found, having myself many other things in hand which I would first complete, and therefore cannot so well attend it. But this I durst promise the undertaker, that he will find all the great motions of the world to be influenced by this principle, and that the true understanding thereof will be the true perfection of astronomy."[38]

[38] In quoting this passage, which Delambre (*Astronomie du 18me Siècle*, pp. 9, 10) admits to be very curious, he scarcely does justice to Hooke when he says that what it contains is found expressly in Kepler. It is quite true that Kepler mentioned as probable the law of squares of the distances, but he afterwards, as Delambre admits, rejected it for that of the simple dis-

"In this remarkable passage," says Brewster, "the doctrine of universal gravitation and the general law of the planetary motions are clearly laid down. The diminution of gravity as the square of the distance is alone wanting to complete the basis of the Newtonian philosophy, but even this desideratum was in the course of a few years supplied by Dr. Hooke." We will speak of this in the seventh section.

VI.

In Hooke's *Cometa* of 1678, he speaks not only distinctly of a "kind of gravitation by which the planets are attracted and have a tendency towards the sun as terrestrial bodies have towards the center of the earth,"[39] but considers comets as probably acted upon by the same force and moving by the effect of it in curvilinear paths.[40]

VII.

Hooke, after Oldenburg's death, became secretary of the Royal Society, and accordingly wrote a friendly letter on November 24, 1679,[41] to Newton, expressing a hope that he would continue to make communications to the Society, and, among other things, asking Newton to communicate to him any objection he might have to Hooke's idea of compounding tangential and central motions, referred to in the third section above. Newton, in his reply of November 28, excused himself from the proposed correspondence on the grounds of a cessation of his interest in "philosophy," but he courteously discussed some of the

tances. Hooke, on the contrary, announces it as a truth. Clairaut has justly remarked that the example of Hooke and Kepler shows how great is the difference between a truth conjectured or asserted and a truth demonstrated. This note is Brewster's.

[39] P. 31.

[40] P. 44. Cf. Rigaud, *op. cit.*, p. 38, and Rouse Ball, *Essay*, p. 157.

[41] Most of the letters, or drafts of them, together with Hooke's comments, in this correspondence between Hooke and Newton are in the Library of Trinity College, Cambridge, and are printed in Rouse Ball's *Essay*, pp. 138-153; cf. pp. 18-24. Cf. also Rosenberger, *op. cit.*, pp. 155, 167-171.

UMI

topics suggested by Hooke, and mentioned that it had occurred to him that a demonstration of the earth's diurnal rotation might be obtained by seeing whether a stone. when falling freely, deviated in an easterly direction from the perpendicular, and added that the free path was part of a spiral which passed through the earth's center. The question simply concerned the composition of the motion of the stone round the earth's axis with its falling motion.[42]

This letter was read to the Society on December 4, 1679; and to this reading refer Waller's[43] words:

"An experiment being suggested to try whether the earth moved with a diurnal motion or not, by the fall of a body from a considerable height, alleging it would fall to the east of true perpendicular, Mr. Hooke read a discourse upon that subject, wherein he explained what the line described by a falling body must be, supposing it to be moved circularly by the diurnal motion of the earth, and perpendicularly by the power of gravity, and showed it would not be a spiral line, but an excentrical-elliptoid, supposing no resistance in the medium, but supposing a resistance, it would be an excentric-ellipti-spiral, which after many revolutions, would rest in the center at last; that the fall of the body would not be directly east but to the south-east, and more to the south than the east. This was tried, in which the ball was still found to fall to the south-east."[44]

On December 9, Hooke wrote again to Newton;[45] the letter is lost, but it seems to have been to the same effect as the communication to the Royal Society. Newton's reply is missing, but Newton wrote to Halley in 1686 that Hooke's "letters occasioned my finding the method of determining figures" described under a central force and

[42] Birch, *History*, Vol. III, 1757, pp. 512-513; Rouse Ball, *Essay*, p. 145.
[43] *Loc. cit.*, p. xxii.
[44] Cf. Birch, *History*, Vol. III, p. 516; Rouse Ball, *Essay*, p. 146.
[45] Rouse Ball, *Essay*, pp. 145, 152.

finding thus the ellipse,[46] and "his correcting my spiral occasioned my finding the theorem by which I afterwards examined the ellipsis."[47]

It must be added that in Hooke's letter of January 6, 1680,[48] the law of attraction (varying as the inverse square of the distance) is explicitly stated,[49] and Newton, in the scholium to the fourth proposition of the second section of the first book of the *Principia,* gave Hooke credit for this.

These are the facts on which was based the controversy between Hooke and Newton about the discovery of the theory of gravitation. We shall here pass over this controversy, and in the next section will give some account of Hooke's fundamental physical views, among which is the beginning of a conception of "mass" as distinct from the Cartesian idea of a plenum of matter whose essence is extension. Hooke considered an ether containing pieces of matter, apparently qualitatively different.

However, we must here give some account of a rather pathetic incident which occurred as a result of the controversy between Hooke and Newton about the discovery of the theory of gravitation.

In 1813, says Rigaud,* a collection of letters was printed from the originals in the Bodleian Library of Oxford, with some biographical notices taken from the manuscripts of J. Aubrey in the Ashmolean Museum of Oxford. Among these last was a letter from Aubrey to A. Wood on the claims of Hooke to the discoveries which were said to pass for Newton's. Aubrey's own authority on such a point is not great, and the letter therefore, as it is printed,

[46] *Ibid.,* p. 165.

[47] *Ibid.,* p. 167.

[48] It must be remembered that at that time in England the year began on March 25, so that this date was then January 6, 1679.

[49] Rouse Ball, Essay, p. 147.

* *Op. cit.,* pp. 41-42.

is not only obscure, but deprived of its real value. The editor has given a long passage which he states to be taken from what is in Hooke's handwriting; but he has inserted it in the wrong place, in such a manner as to make it appear to be merely a loose paper which Aubrey had sent to his correspondent. By a reference however to the the original, it was found that the letter must have been written under Hooke's immediate direction; it is not only corrected and altered by him in many places, but by far the greater part consists of additions which he has made with his own hand. This letter is reproduced by Rigaud.* As Rigaud's work is rather rare we will here reproduce the letter of Aubrey and Hooke spoken of.

"Sept. 15, 1689.

"Mr. Wood!

"Mr. Rob. Hooke, R.S.S., did in anno 1670 write a discourse called, An Attempt to prove the Motion of the Earth, which he then read to the Royal Society; but printed it in the beginning of the year 1674....† to Sir John Cutler, to whom it is dedicated, wherein he has delivered the theory of explaining the celestial motions mechanically; his words are these, pag. 27, 28. viz.‡

"About 9 or 10 years ago Mr. Hooke writ to Mr. Isaac Newton of Trin. Coll. Cambridge, to make a demonstration of [it] *this Theory, not* telling him *at first* the proportion of the gravity to the distance, [and] *nor what was* the curved line that was thereby made.

"Mr. Newton [did express], in his answer to the letter, *did* express that he had not thought§ of it; and in his first

* *Ibid.*, pp. 52-55 of Appendices. In the following letter, whatever was inserted by Hooke is in italics. Aubrey's words are enclosed in square brackets when they have been erased in order that others might be substituted for them.

† The words here are not legible, but probably they make mention of Hooke "as lecturer to Sir John Cutler," or something to that purport.

‡ Here a space is left in which Aubrey evidently intended to insert the passage.

§ "known" is written over "thought"; but the first word is not erased.

attempt about it, he calculated the curve by supposing the attraction to be the same at all distances: upon which Mr. Hooke told him in his next letter the whole of his Hypothesis, scil. that the gravitation was reciprocal to the square of the distance, *which would make the motion in an ellipsis, in one of whose foci the sun being placed, the aphelion and perihelion of the planet would be opposite to each other in the same line, which is the whole celestial theory, concerning which Mr. Newton hath made a demonstration,* not at all owning he received the first intimation of it from Mr. Hooke. Likewise Mr. Newton has in the same book printed some other theories and experiments of Mr. Hooke's *as that* about the oval figure of the earth and sea, without acknowledging from whom he had [it] *them, though he had not sent it up with the other parts of his book, till near a month after this theory was read to the Society by R. H.,* (Mr. Hooke,) *when it served to help to answer Dr. Wallis his arguments produced in the R. S. against it.*

"In the Attempt to prove the Motion of the Earth, etc., printed 1674, but read to the Royal Society 1671, pag. 27, lin. 31.

" 'I shall only for the present hint, that I have, in some of my foregoing observations, discovered some new motions even in the earth itself, which perhaps were not dreamt of before, which I shall hereafter more at large describe, when further trials have more fully confirmed and completed these beginnings. .At which time also I shall explain a system of the world. But these degrees and proportions of the power of attraction in the celestial bodies and motions were communicated to Mr. Newton by R. Hooke in the year 1678 by letters, as will plainly appear both by the copies of the said letters, and the letters of Mr. Newton in answer to them, which are both in the custody*

* Here follows the extract already reproduced in § V above down to "experimentally verified."

*of the said R. H., both which also were read before the Royal Society at their public meeting, as appears by the Journal Book of the said Society.'**

"Mr. Wood!

"This is the greatest discovery in nature, that ever was since the world's creation: it never was so much as hinted by any man before. I know you will do him right. I hope you may read his hand: I wish he had writ plainer, and afforded a little more paper.

Tuus,

"J. AUBREY....

"Before I leave this town I will get of him a catalogue of what he hath wrote, and as much of his inventions as I can; but they are many hundreds; he believes not fewer than a thousand. 'Tis such a hard matter to get people to do themselves right."

Other letters† in the Bodleian, of which Rigaud's extracts are given here, show that Hooke had been incessantly urging Aubrey to procure some notice of him by Wood. Thus:

"London, Sept. 15, 1674. Mr. Hooke told me, (who has looked over your book‡), that you have left out several eminent men. You have not either mentioned him, which I desired. England has hardly produced a greater wit, viz. for mechanics."

"Gresham Coll., March 2, 1691-2. Mr. Wood! I acquainted you, some weeks since, that Mr. Hooke (now Dr. Hooke) desired you to do him the favor to send him a transcript of what you are to print concerning him. I have not yet heard from you about it: and Dr. Hooke doth again

* In the Journal Book of the Royal Society there is no mention of any such correspondence in 1678, or in 1679 till December. It was a mistake therefore in Hooke to refer to the former of these two years.

From this point the quotation, *"But it is a notion....the true perfection of astronomy,"* is resumed.

† *Ibid.*, pp. 56-57 of Appendices.

‡ *Historia et Antiquitates Univers. Oxon.*; published in 1674.

this day earnestly desire you would be pleased to write as aforesaid, as soon as you can possibly: for it doth (he says) exceedingly concern him. He will repay you for the transcription, which I shall deliver to you when I come to you."

"London, March 3, 1691-2. Mr. Wood! I sent you a letter some weeks since that Dr. Hooke remembers him very kindly to you, and does earnestly request you to do him the favour to send him a transcript of what you intend to write of him, with all possible speed; and he will repay you for the transcribing. To this purpose I yesterday left a letter with Mr. Bennet; but to-day speaking with Mr. Bennet, he tells me that he sent a letter from you to me, by the penny-post, on Saturday last: my landlady affirms she received it not. Now your book* drawing to an end, I, not knowing what the consequence of that letter may be, thought it a sure way to trouble [you] with this letter by the post."

"April 13, 1692, Gresham College. Dr. Hooke does again desire, if you do make any mention concerning him, you would favour him with a copy of it, before it goes to the press, and he will gratify you in anything that is equivalent. He remembers him kindly to you, and will be ready to serve you in any thing that may lie in his way."

VIII.

To "A Discourse of the Nature of Comets; read at the Meetings of the Royal Society soon after *Michaelmas*, 1682," in Hooke's *Posthumous Works*,[50] "we have.... here annexed," says Waller,[51] "a pretty large, and (if I may be allowed to speak) an ingenious discourse of gravity or gravitation. The running title will direct the reader to it. In this he considers the most known properties of

* *Athenae Oxonienses*, of which the first edition was completed and published in 1692.

[50] *Posthumous Works*, pp. 149-185; cf. Rosenberger, *op. cit.*, pp. 156-157.

[51] *Posthumous Works*, pp. 149-150.

the celestial bodies, and having made several deductions from observations, as to the nature of the ether, air, and the like, in which *in transitu* he explains thunder and lightning, asserting a levitation, as well as gravitation (or a receding from, as well as tendency towards the center); having also shown that the ether or vast fluid *expansum* is the medium to convey the motions of gravitation as well as light; he comes in the next place to treat more particularly of body and motion, explaining what he understands by each of them, and then treating of motion, says that the two great laws of motion are light and gravity, and, having before treated of the former, he comes to explain the latter more particularly when, having shown that there is such a thing as gravity, with the limits and proportions of its power, and that it exerts it in all bodies, he comes at last to the principal part, the cause of gravity, and after the enumeration of its properties, gives his explication and hypothesis of the cause thereof. The author designed to have answered several objections against this his hypothesis, but having replied to one only, the discourse ends. To supply this defect, I have added some fragments which I found relating to the same subject, which the reader will find immediately annexed."

"All solid celestial bodies, then," says Hooke,[52] "have two properties; first a faculty of emitting or reflecting light; secondly an orbicular figure.... The second property of their orbicular or spherical form is an indication of another active principle which I conceive universal to all solid bodies in nature, and that is, of a gravitation or power of attracting similar solid bodies towards their centers. Which two principles I take to be the most considerable and the most active in nature and those from which the most considerable effects are produced; and when they are understood and explained as they ought, I

[52] *Ibid.*, p. 166.

question not but that they will afford us solutions and reasons for a thousand phenomena, the explication of which does now so much puzzle and perplex us."

From his observation he deduced,[53] among other things, that "the power of gravitation is extended into the ether, without the atmosphere of bodies, and consequently that the atmosphere or air is not the cause of gravitation, but rather the ether, in which the atmosphere or air is but a kind of dissolution, as salt or tinctures are dissolved in water or other liquors, and that from thence comes even the gravitation of the atmospheres to their incompassed bodies; which we observe by many other experiments made here upon the earth. For it is evident that bodies in a receiver, exhausted or emptied of the air by means of the exhausting engine, or any other ways, have not less of gravity towards the perpendicular or center of the earth than the bodies in the open and free air; nay they are found to be proportionably heavier, by how much a body of the air, equal to them in bulk, has been found to be lighter than them; which is an experiment that has often been tried."

To prove these deductions, Hooke demonstrated "four particulars"; first explaining what notions his expressions are meant to convey.[54]

"I conceive then the whole of realities that any ways affect our senses to be body and motion. By body I conceive nothing else but a reality that has extension every way, positive and immutable, not as to figure but as to quantity; and that the body, as body, is the same whatever figure it be of, as a quart of water is a quart of water, or a certain quantity of body, though contained in a globe, cylinder, cone, cube, quart pot, or any other figured containing vessel: and as body, it is indifferent to receive any figure whatever; nor has it more extension in one than in

[53] *Ibid.*, pp. 168-169.

[54] *Ibid.*, pp. 171-172.

the other vessel, nor can it have less; nor is it more essentially a body when solid, as ice, than when fluid; that is, the minims of it are equally disposed to motion or rest in position to each other; and therefore body, as body, may as well be, or be supposed to be indefinitely fluid as definitely solid; and consequently there is no necessity to suppose atoms, or any determinate part of body perfectly solid, or such whose parts are incapable of changing position one to another; since, as I conceive, the essence of a body is only determinate extension, or a power of being unalterably of such a quantity, and not a power of being and continuing of a determinate quantity and a determinate figure, which the anatomists suppose. These I conceive the two powers or principles of the world, to wit, body and motion; uniformity of motion making a solid and difformity of the motion of the parts making a fluid, as I shall prove more at large by and by.

"By motion I understand nothing but an alteration, or power of alteration of the minims of a whole in respect of one another, which power may be increased or diminished in any assignable quantity; but the natural balance of the universe is reciprocal to the bulk or extension, or to the quantity of the other power, body.

"These two I take to be two single powers, which cooperate in effecting the most of the sensible and insensible effects of the world."

And again:[55]

"As for matter, that I conceive in its essence to be immutable, and its essence being expatiation determinate, it cannot be altered in its quantity either by condensation or rarefaction; that is, there cannot be more or less of that power or reality, whatever it be, within the same expatiation or content; but every equal expatiation contains, is filled, or is an equal quantity of *materia*; and the

[55] *Ibid.*, pp. 172-173.

densest or heaviest, or most powerful body in the world contains no more *materia* than that which we conceive to be the rarest, thinnest, lightest, or least powerful body of all; as gold, for instance, and ether, or the substance that fills the cavity of an exhausted vessel, or the cavity of the glass of a barometer above the quicksilver. Nay, as I shall afterwards prove, this cavity is more full, or a more dense body of ether, in the common sense or acceptation of the word, than the gold is of gold, bulk for bulk; and that because the one, viz., the mass of ether, is all ether; but the mass of gold which we conceive is not all gold but there is an intermixture, and that vastly more than is commonly supposed, of ether with it; so that the vacuity, as it is commonly thought, or erroneously supposed, is a more dense body than the gold as gold. But if we consider the quantity of the whole content of the one with that of the other, within the same or equal quantity of expatiation, then are they both equally containing the *materia* or body.

"This possibly may at first hearing seem a little paradoxical, if not absurd; however I doubt not but that by the sequel of my discourse I shall be able to make it somewhat more plausible, if not positively and undeniably demonstrate it so to be.

"The second principle or power, which is motion, is of a quite differing nature, and may be rarified and condensed, diminished or increased, within the same quantity of body or matter, in any proportion assigned; that is, the same quantity of the first power, body or part of matter, may receive any assignable quantity of the second, that is, any assignable degree of motion; and being possessed of it, it may communicate or lose any assignable part of what it has, and still the body, as body, remain unaltered and the same; for as it may be moved with any motion, how swift soever it be supposed; so may it move with indefinitely slow motions, and that so far as that the next step one

would suppose it must lose all its motion, and remain in entire rest, and unalterable of position, as to the contiguous body."

With regard to the second of the "great laws of motion which constitute the form and order of the world"—gravity, the first being light, Hooke[56] says:

"By gravity then I understand such a power as causes bodies of a similar or homogeneous nature to be moved one towards the other till they are united; or such a power as always impels or drives, attracts or impresses motion into them, that tends that way, or makes them unite. The universality of this principle throughout the whole and everything therein I shall afterwards have more occasion to explain when I come to the effects of nature in the lesser bodies. At present I shall only proceed to show it in the greater bodies of the world."

"There have been," says Hooke,[57] "as many differing opinions concerning the limits of this power: some extending it too far, and others as extravagantly too little; some supposing that wheresoever in the universe a terrestrial body should be placed, there it would have a tendency towards the center of the world or earth; and therefore that in the creation all the terrestrial matter of the chaos met together and made up the body of the earth. Others, on the other hand, have been too penurious in limiting its power to some few miles; some to fifty miles, others to a boundary that a cannon well charged with powder would be able to shoot a bullet out of its reach. But though they are both enough mistaken, yet they agree in this, that this power of gravitation does act at some distance above the surface of the earth."

On the next page, Hooke[58] asserts:

[56] *Ibid.*, p. 176.
[57] *Ibid.*, p. 177.
[58] *Ibid.*, p. 178.

"I say, moreover, that this power is not only placed in the earth, but that there is the like power in every globular body in the universe, whether sun or fixed star, planet primary or secondary, and in the cometical body included, as I have supposed, within the nucleus of white cloud appearing in the head."

There are many other intelligent remarks on gravity and the explanation by its means of celestial motions. But here our object is to collect what details we can of the growth and the conception of mass and its connection with "the quantity of matter."

The bodies most receptive of gravity, according to Hooke,[59] "are such as have their particles of the greatest bulk and of the closest texture. This the whole series of grave bodies will sufficiently manifest; and I shall afterwards prove, when I come to show the texture of body, what it is that causes bodies to be grave or heavy and what makes them light, and that it is not the quantity of matter contained within the same space, but the modification of that matter, and the receptivity it hath of uniform power."

"I cannot find by any certain experiment," says Hooke,[60] "that grave bodies do sensibly decrease in gravity, though further removed from the surface of the earth; which was the intent to an experiment I formerly tried at the top of the steeple of St. Paul's and at Westminster Abbey, and may now again be repeated with much more conveniency and greater advantage at the column on Fishstreet Hill. For by counterpoising two weights in a curious pair of scales, first at the top of the steeple and then letting down one of the weights by a wire of two hundred and four feet in length, the counterpoise remaining at the top in the scale, the *aequipondium* remained: whereas if the gravity

[59] *Ibid.*, p. 182.
[60] *Ibid.*, pp. 182-183

of the body had increased by approximation to the earth, the weight let down to the bottom must have weighed the heavier. But though the difference were insensible in so small an height, yet I am apt to think some difference may be discovered in greater heights, and in some more curious ways than those I then used, even in that height; for I shall in my following discourses plainly show from the theory thereof that there is necessarily a difference and that the power of gravity does decrease at farther and farther distance from the center of the earth, and consequently that the line of a projected descending body is not truly parabolical, but elliptical though it should be made *in vacuo,* where the impediment of the medium could make very little or no alteration."

Then he deals[61] with his hypothesis as to the cause of gravity:

"Suppose then that there is in the ball of the earth such a motion, as I, for distinction's sake, will call a globular motion, whereby all the parts thereof have a vibration towards and fromwards the center, or of expansion and contraction; and that this vibrative motion is very short and very quick, as it is in all very hard and very compact bodies: that this vibrative motion communicates or produces a motion in a certain part of the ether which is interspersed between these solid vibrating parts: which communicated motion causes this interspersed fluid to vibrate every way *in orbem,* from and towards the center, in lines radiating from the same. By which radiating vibration of this exceeding fluid and yet exceeding dense matter, not only all the parts of the earth are carried or forced down towards the center; but the motion, being continued into the ether interspersed between the air and other kinds of fluid, causes those also to have a tendency towards the center; and much more any sensible body whatever that is

[61] *Ibid.,* pp. 184-185.

anywhere placed in the air or above it, though at a vast distance; which distance I shall afterwards determine and show with what proportioned power it acts upon bodies at all distances both without and within the earth: for this power propagated, as I shall then show, continually diminishes according as the orb of propagation continually increases, as we find the propagations of the media of light and sound also to do; as also the propagation of undulation upon the superficies of water. And from hence I conceive the power thereof to be always reciprocal to the area of superficies of the orb of propagation, that is duplicate of the distance; as will plainly follow and appear from the consideration of the nature thereof, and will hereafter be more plainly evinced by the effects it causes at such several distances.

"This propagated pulse I take to be the cause of the descent of bodies towards the earth. But it may perhaps seem a little strange how the propagation of a motion outward should be the cause of the motion of heavenly bodies downwards. To make this the more intelligible, I shall mention an observation very commonly known amongst tradesmen; and that is, the driving of a hammer or axe upon the helve, which to do the easiest way, they commonly strike the end of the helve, holding the helve in their hand and the axe or hammer at the lower end hanging downward, by which means they not only make the axe to go on upon the helve, but make it ascend, if they continue striking, even to their very hand. To apply which observation to my present theory, I say that the medium of propagation is the helve, and the axe or hammer is the grave body that descends; so that at every stroke that is given by the globe of the earth to the propagating medium, one degree of velocity of descent is given to the grave body which is as it were the axe. Now according to the velocity of this vibrative motion of the earth, so must the power it commu-

nicates be stronger or weaker. Suppose for instance, there should be a thousand of these pulses in a second of time, then must the grave body receive all those thousand impressions within the space of that second, and a thousand more the next, and another thousand the third second, so that in equal times it would receive equal degrees of acceleration. And if a second of time were again subdivided into a thousand moments of time, the body would receive one degree of acceleration in the first moment, one more in the second, a third in a third, and so onwards; so that the compounded acceleration would be as one in the first second, three the next second and five the next, and so onwards; according as it is observed in the motion of descending bodies.

"The medium that propagates this motion, I suppose to be one part of that which permeates most bodies, which we call by the general name of ether, and thence it proceeds that the motion is communicated to every part thereof: and so the momentum of every body becomes proportioned to its bulk or density of parts, difform to the fluid medium that communicates the pulse."

Then he[62] begins to discuss objections that might be urged against it, when the manuscript breaks off abruptly.

Among the loose papers of Hooke's which are printed after this is "An Account of Dr. Isaac Vossius's Hypothesis of Gravitation, with some animadversions thereupon."[63]

PHILIP E. B. JOURDAIN.

CAMBRIDGE, ENGLAND.

[62] *Ibid.*, p. 185.

[63] *Ibid.*, pp. 201-202.

THE NEW MECHANICS.[1]

IN this world, as you know, nothing is final, nothing immutable; the most powerful, the most stable empires are not eternal: this is a theme the preachers abundantly develop.

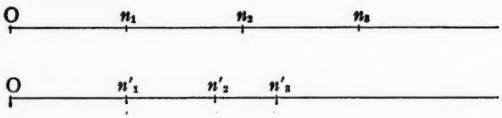
Scientific theories are like empires, they are not certain of the morrow. If any one of them seemed beyond the effects of time, it was certainly the Newtonian mechanics. It seemed undisputed, it was an imperishable monument; and behold in its turn, I shall not say the monument is thrown down, that would be premature, but anyhow it is greatly shaken. It is subjected to the attacks of powerful destroyers. There is one in Göttingen, Max Abraham, another is the Dutch physicist Lorentz. I wish to say a few words about the ruins of the ancient edifice and about the new structure by which it is sought to replace them.

First of all what is it that characterizes the old mechanics? It is this very simple fact: Consider a body at rest, impart to it an impulse, that is to say make a given force act upon it for a given time; the body moves, acquires a certain velocity; the body being impelled by this velocity, apply to it again the same force for the same time, the velocity will be doubled; if we still continue, the velocity will be tripled when we shall have given a third time the same impulse. So beginning again a sufficient number of times, the body will end by acquiring a very great velocity which can exceed all limit, an infinite velocity.

[1] Translated from the French by George Bruce Halsted.

In the new mechanics, on the contrary, we assume it to be impossible to communicate to a body starting from rest a velocity beyond that of light. What happens? Consider the same body at rest; give it a first impulse, the same as before, it will take the same velocity; repeat this impulse a second time, the velocity again augments, but it no longer will be doubled; a third impulse will produce an analogous effect, the velocity increases but less and less, the body opposing a resistance which becomes greater and greater. This resistance is inertia, it is what is commonly called mass; all this happens then in this new mechanics as if the mass was not constant, but increased with the velocity.

We can represent the phenomenon graphically: In the old mechanics the body after the first impulse takes a velocity represented by the sect On_1; after the second impulse On_1 increases by a sect n_1n_2 equal to it; at each new



impulse the velocity increases by the same quantity, the sect representing it increasing by a constant length. In the new mechanics, the velocity sect increases by sects $n'_1\,n'_2$, $n'_2\,n'_3$,.... which become smaller and smaller so that we cannot pass beyond a certain limit, the velocity of light.

How have we been led to such conclusions? Have we made direct experiments? The divergences only come out for bodies impelled by great velocities; only then do the indicated differences become perceptible. But what is a very great velocity? Is it that of an automobile making 100 kilometers an hour? We would go wild with excitement over such a speed in the street. But from our

point of view this velocity is still very small, a snail's pace. Astronomy does better. Mercury, the fastest of the heavenly bodies, also runs over about 100 kilometers, no longer per hour but per second. However, that still does not suffice; such velocities are too slight to reveal the differences we wish to observe. I do not mention our cannon balls; they are faster than automobiles, but much slower than Mercury.

You know that we have discovered an artillery whose projectiles are much swifter; I mean radium which sends out energy projectiles in every direction. The speed of this shooting is far greater, the initial velocity being about 100,000 kilometers a second, one-third the velocity of light. The caliber of the projectiles and their weight are, it is true much slighter and we cannot count on this artillery to increase the fighting power of our armies.

Can we experiment on these projectiles? Such experiments have been actually undertaken; under the influence of an electric field, of a magnetic field, a deviation occurs which enables us to take account of the inertia and to measure it. Thus we have ascertained that the mass depends upon the velocity and we enunciate this law: The inertia of a body increases with its velocity which remains less than that of light, 300,000 kilometers a second.

I pass now to the second principle, the principle of relativity. Suppose there is an observer moving to the right; everything is as if he were at rest, with the objects about him moving to the left. There is no way of knowing whether the objects really move, whether the observer is at rest or in motion. We teach in all courses on mechanics that the passenger on a boat thinks he sees the river bank moving, while he is gently borne along by the motion of the boat. Examined more closely, this simple idea acquires capital importance; there is no way of settling the question, no experiment can disprove the principle that there is no

absolute space, all displacements we can observe are relative displacements. I have often had occasion to express these considerations so familiar to philosophers. They have even given me a publicity I would gladly have avoided. All the reactionary French journals have made me prove that the sun turns around the earth. In the famous case between the Inquisition and Galileo, Galileo should be all wrong.

To return to the old mechanics. It admitted the principle of relativity; in place of being founded on experiments, its laws were deduced from this fundamental principle. These considerations sufficed for purely mechanical phenomena, but not for important parts of physics, for example optics. We considered the velocity of light as absolute with reference to the ether. This velocity could be measured. We had theoretically the means of comparing the displacement of a moving body to an absolute displacement, the means of deciding whether or not a body was in absolute motion.

Delicate experiments, apparatus exceedingly precise, which I shall not describe to you, enabled us to attempt the practical realization of such a comparison: the result was null. The principle of relativity admits of no restriction in the new mechanics; it has, if I may so speak, an absolute value.

To understand the rôle the principle of relativity plays in the new mechanics, we are led first to speak of apparent time, a very ingenious invention of the physicist Lorentz. We suppose two observers, the one A at Paris, the other B at Berlin. A and B have identical chronometers and wish to set them; but they are exceptionally scrupulous observers and require in their setting an extraordinary exactitude not only, for instance, to the second, but to the thousand-millionth of a second. How can they do it? From Paris to Berlin, A sends a telegraphic signal, by wireless,

if you will, to be wholly modern. B notes the moment of reception and this will be the starting time for both chronometers. But it takes a certain time for the signal to go from Paris to Berlin; it travels only with the speed of light. B's watch would therefore be slow. B is too intelligent not to take this into account, and he proceeds to remedy it. The thing seems very simple. They cross signals, A receiving and B sending; they take the mean of the corrections thus made and so have the exact time.

But is this certain? We are assuming that it takes the signal the same time to go from A to B as from B to A. Now A and B are carried along in the motion of the earth with reference to the ether, the vehicle of the electric waves. When A has sent his signal it flies on before him, B moving away in the same way, and the time employed will be longer than if the two observers were at rest. If, on the other hand, it is B who sends, and A who receives, the time is shorter because A goes to meet the signal. It is absolutely impossible for them to know whether or not their chronometers mark the same time. Whatever the method employed, the troubles remain the same. The observation of an astronomic phenomenon and all optical methods run against the same difficulties. B can never know more than an apparent difference of time, more than a species of local hour. The principle of relativity applies completely.

In the old mechanics, however, we prove with this principle all the fundamental laws. We might be tempted to take up the classic arguments and reason as follows. Suppose again two observers, A and B, to call them what we always call two observers in mathematics. Suppose them in motion, going away from each other. Neither can surpass the velocity of light; for example let B go at the rate of 200,000 kilometers toward the right, A of 200,000 kilometers toward the left. A may think himself at rest, and

the apparent velocity of B will for him be 400,000 kilometers. If A knows the new mechanics he will say: "B has a velocity he cannot attain, therefore I also am in motion." It seems he could decide about his absolute state. But he must be able to observe the motion of B himself. To make this observation A and B commence by setting their watches, then B sends telegrams to A to indicate to him his successive positions; putting them together A can reckon B's motion and trace the curve of this motion. Now the signals go with the speed of light. The watches which mark the apparent time vary at each instant and everything will happen as if B's watch went too fast. B will think himself going much less rapidly and the apparent velocity he will have relatively to A will not surpass the limit it should not attain. Nothing can reveal to A whether he is in motion or at absolute rest.

It is still necessary to make a third hypothesis, which is much more surprising, much more difficult to admit, and which greatly disturbs our present modes of thought. A body in motion of translation undergoes a deformation in the direction of its displacement; a sphere, for instance, becomes like a species of flattened ellipsoid with the short axis parallel to the translation. If we do not perceive such a transformation every day this is because it is so small as to render it almost imperceptible. The earth, borne along in its revolution through its orbit, is deformed about $^1/_{200\,000\,000}$. To observe such a phenomenon would require measuring instruments of extreme precision, but if their precision were infinite it would not avail, because they also are borne along in the motion and would undergo the same transformation. We should perceive nothing; the meter we could use would shorten like the length to be measured. We could not learn anything except by comparing the length of one of these bodies to the velocity of light.

These are delicate experiments, carried out by Michelson and I shall not expound their details; they have given results altogether remarkable. However strange it may seem to us, it is necessary to admit that the third hypothesis is perfectly verified.

Such are the bases of the new mechanics; with the help of these hypotheses we find that it is compatible with the principle of relativity.

But it is necessary to connect it then to a new conception of matter.

For the modern physicist, the atom is no longer the simple element; it has become a veritable universe in which thousands of planets gravitate around tiny suns. Suns and planets are here particles *electrified* either negatively or positively; the physicist calls them *electrons* and with them builds the world. Some represent the neutral atom as a positive central mass around which circulate a great number of negatively charged electrons, whose total electric mass equals in magnitude that of the central nucleus.

This conception of matter enables us easily to account for the augmentation of the mass of a body with its velocity, which we have made one of the characteristics of the new mechanics. Since a body is only an assemblage of electrons, it will suffice to show it to be true of them. To this end we note that an isolated electron moving through the ether engenders an electric current, that is to say an electromagnetic field. This field corresponds to a certain quantity of energy localized not in the electron but in the ether. A variation in magnitude or in direction of the electron's velocity modifies the field and expresses itself by a variation of the electromagnetic energy of the ether. While in the Newtonian mechanics the expenditure of energy is due only to the inertia of the moving body, here a part of this expenditure is due to what may be called the

inertia of the ether relatively to the electromagnetic forces. The inertia of the ether increases with the velocity and its limit becomes infinite when the velocity approaches the velocity of light. The apparent mass of the electron therefore increases with the velocity; Kaufmann's experiments show that the constant real mass of the electron is negligible in relation to the apparent mass and may be considered as null.

In the new conception, matter's constant mass has disappeared. Only the ether, and no longer matter, is inert. Only the ether opposes a resistance to motion, so that we might say that there is no matter, but only gaps in the ether. For stationary or quasi-stationary motions, the new mechanics does not differ—within the range of approximation of our measurements—from the Newtonian mechanics, with the sole difference that the mass is no longer independent either of the velocity or of the angle this velocity makes with the direction of the accelerative force. If, *per contra,* the velocity has a considerable acceleration, in the case, for instance, of very rapid oscillations, Hertzian waves are produced which represent a loss of energy of the electron involving the deadening of its motion. Thus in wireless telegraphy the waves emitted are due to the vibrations of the electrons in the oscillatory discharge.

Analogous vibrations take place in a flame and likewise also in an incandescent solid. Lorentz thinks that in an incandescent body a considerable number of electrons circulate which, not being able to get out of it, fly in every direction and are reflected on its surface. We may compare them to a swarm of gnats enclosed in a jar and striking with their wings against the walls of their prison. The higher the temperature, the more rapid becomes the motion of these electrons and the more numerous the mutual impacts and the reflections on the wall. At each im-

pact and at each reflection an electromagnetic wave is emitted and it is the perception of these waves which makes the body appear to us incandescent.

The motion of the electrons is almost tangible in a Crookes tube. There a veritable bombardment takes place of electrons issuing from the cathode. These cathode rays violently strike the anticathode and are there in part reflected, thus giving birth to an electromagnetic agitation which many physicists identify with the Röntgen rays.

In closing, it remains for us to examine the relations of the new mechanics to astronomy.

If the notion of constant mass of a body vanishes, what will become of Newton's law? It will hold good only for bodies at rest. Moreover it will be necessary to take into account the fact that attraction is not instantaneous. It may therefore well be asked whether the new mechanics will not result in complicating astronomy without obtaining an approximation superior to that given by the classic celestial mechanics. Lorentz has taken up the question. Starting from Newton's law, which he assumes to be true for two electrified bodies at rest, he calculates the electrodynamic action of the currents engendered by these bodies in motion. He thus obtains a new law of attraction containing the velocities of the two bodies as parameters.

Before examining how this law explains astronomic phenomena, we remark again that the acceleration of the heavenly bodies has as consequence an electromagnetic radiation, therefore a dissipation of energy making itself felt in return by a deadening of their velocity. Therefore, in the long run, the planets will end by falling into the sun. But this prospect can hardly frighten us, since the catastrophe can not happen for some millions of milliards of centuries.

Returning now to the law of attraction, we easily see

that the difference between the two mechanics will be the greater the greater the velocity of the planets.

If there is an appreciable difference, it will therefore be greatest for Mercury, which has the greatest velocity of all the planets. Now it happens precisely that Mercury presents an anomaly not yet explained. The motion of its perihelion is more rapid than the motion calculated by the classic theory. The acceleration is 38″ too great. Leverrier attributed this anomaly to a planet not yet discovered and an amateur astronomer thought he observed its passage across the sun. Since then no one else has seen it and it is unhappily certain that this planet perceived was only a bird.

Now the new mechanics explains perfectly the sense of the error with regard to Mercury, but it still leaves a margin of 32″ between it and observation. It therefore does not suffice for bringing concord into the explanation of the velocity of Mercury. If this result is hardly decisive in favor of the new mechanics, still less is it unfavorable to its acceptance since the sense in which it corrects the deviation from the classic theory is the right one. Our explanation of the velocity of the other planets is not sensibly modified in the new theory and the results coincide, to within the approximation of the measurements, with those of the classic theory.

In conclusion, it would be premature, I believe, in spite of the great value of the arguments and of the facts set up against it, to regard the classic mechanics as finally condemned. However it may be in other respects, it will remain the mechanics of very small velocities in relation to that of light, the mechanics therefore of our practical life and of our terrestrial technic. If however, in some years, its rival triumphs, I shall venture to point out a pedagogic danger that a number of teachers, in France at least, will not escape. These teachers will find nothing

more important, in teaching elementary mechanics to their scholars, than to inform them that this mechanics has had its day, that a new mechanics where the notions of mass and of time have a wholly different value replaces it; they will look down upon this lapsed mechanics that the programs force them to teach and will make their scholars feel the contempt they have for it. Yet I believe that this disdained classic mechanics will be as necessary as now and that whoever does not know it thoroughly cannot understand the new mechanics.

HENRI POINCARÉ.

HISTORY OF PLANT HYBRIDS.[1]

I. BEFORE 1761.

KNOWLEDGE of the existence of hybrids between various species of animals, especially between the horse and the ass, reaches back into the dim past. The conception of the possibility of hybridizing plants arose as soon as the sexuality of the higher plants became known. Toward the end of the seventeenth century it appears that simultaneously in several botanists the view took root that the stamens are the male organs of the flowering plants. In the year 1676 Grew brought before the Royal Society in London, in a paper which was published in 1682, Sir Thomas Millington's ideas concerning the sexual functions of anthers, which had not until then been made known.

The theory of the sexuality of the higher plants became more firmly grounded through Rudolf Jacob Cammerer (Camerarius) of Tübingen, who made his first experiments in 1691, and in 1694 published his *Epistola de Sexu Plantarum*. At that time he called attention to the possibility of the origin of plant hybrids, and later this question was often discussed by scientists but mainly only theoretically.

J. G. Gmelin saw several new larkspurs originate in his garden and decided upon their hybrid origin.

Linnaeus arrived at the opinion that the self-evident relationships of the species of plants could be explained

[1] Translated from the German by F. L. and E. H. Lewton.

by a common descent. He derived all the species which agreed in the construction of their flowers from the same mother stock, and all those plants resembling one another in form and shape of leaves from the same father stock. Following this same thought farther it appeared to him possible that the entire kingdom of plants was derived from a comparatively small number of originally created basic types. Holding this opinion, the study of newly-formed plant hybrids naturally had for him a special importance. One cannot state that he was especially fortunate in these investigations; upon superficial resemblance he declared as hybrids a number of plant forms which were of widely different parentage. Among those which were named spontaneous hybrids by him there are found only a few true hybrids. One of these is *Verbascum lychnitis* × *Thapsus*. But Linnaeus began to inaugurate experiments in artificial hybridization and with a little more patience would have arrived at important conclusions. He pollinated, for example, *Mirabilis longiflora* with pollen from *M. Jalapa,* an experiment which need only to have been reversed in order to have arrived at a remarkable hybrid. Linnaeus seems to have achieved good results in the crossing of *Tragopogon pratensis* and *T. porrifolius*. So far as I know no one has repeated the experiment, but the objections which have been brought forth by Koelreuter and others against the hybrid nature of the crosses described by Linnaeus can not be regarded as refutations because they refer to plants in the second generation. Linnaeus's *Tragopogon* is therefore, probably, the first plant hybrid originated for scientific purposes. It bloomed in 1759. Already much earlier, and even before 1719, an English gardener, Thomas Fairchild, had successfully crossed two pinks. The hybrid thus achieved, *Dianthus caryophyllus* × *D. barbatus,* was grown 100 years later in English gardens, and perhaps still is, as Fairchild's Sweet William.

This success in artificial fertilization was neither used for science nor does it seem to have given the gardeners an incentive to further investigations.

In spite of these isolated successful crosses the true history of plant hybridization does not begin before 1761; all that went before has more or less a traditional character, the few facts are buried beneath doctrinarian fantasies. As we have already said, Linnaeus made the attempt to gain firm ground in this realm, but it was Koelreuter who really founded the study of plant hybridization.

II. 1761—1799.

Joseph Gottlieb Koelreuter (born April 27, 1733, in Sulz on the Neckar; died at Karlsruhe, November 12, 1806) succeeded, after several unsuccessful attempts with other plants, in getting seed from a plant of *Nicotiana rustica* which he had fertilized with the pollen of *N. paniculata*. The hybrid plants derived from the above, bloomed in 1761. In this same year (1761) appeared the *Vorläufige Nachricht von einigen das Geschlecht der Pflanzen betreffenden Versuchen und Beobachtungen,* in which Koelreuter tells about his hybrid. In the same manuscript he told of a series of experiments whose full importance has only lately been recognized. He discovered the part played by insects in the fertilization of flowers; he determined the number of pollen grains which are needed for complete fertilization; and he gathered the nectar of flowers and showed that it was a solution of honey. In spite of the slight sympathy which he met with, Koelreuter continued his experiments and observations for several decades. All the essential characters of plant hybrids were correctly recognized by him. He fertilized, for example, a plant of *Nicotiana rustica* and its descendants regularly with pollen from *N. paniculata* through a period of generations (up to 20). In this way he transformed the first named species

into the second, and then with pollen of *N. rustica* brought it back again to the original mother form. He tried similar experiments with several species of *Dianthus*. He found out that the hybrid progeny of two species generally show an intermediate type and as a rule resemble each other exactly, it being immaterial which of the two types was used as the mother or father stock. The fertility of the crosses between several varieties of one species; the sterility or diminished fertility of hybrids between different species; the, as a rule, conspicuously greater growth of hybrids; and a mass of other remarkable facts were all carefully observed by Koelreuter. Although he knew of a number of cases of the spontaneous origin of garden hybrids, he never succeeded in finding natural plant hybrids. His successful crosses are principally between the species of the genera *Aquilegia, Matthiola, Dianthus, Melandryum, Linum, Malva, Lavatera, Lobelia, Nicotiana, Datura, Lycium, Verbascum, Digitalis,* and *Mirabilis.* But entirely apart from hybridization Koelreuter could through careful observation take glimpses into the household of Nature, the importance of which was not recognized till a hundred years later. Those important discoveries which were given in his first essay, have already been mentioned. Besides these he recognized the impossibility of the self-fertilization of many species of plants and the distribution by means of birds of plants bearing berries. He also made far-reaching investigations concerning the form of pollen grains.

Koelreuter's contemporaries gave his researches comparatively little attention, but science is indebted to the St. Petersburg Academy for the publication of his later works. With the exception of him and his brother Christoph Cunrad, hybrid plants seem only to have been raised by a few gardeners and flower lovers. For example *Papaver somniferum* × *P. orientale* in the Botanic Garden

at Edinburgh, also *Pelargoniums* by Wiegmann, Zeyher and others. It was not until 30 years later that Hedwig repeated the fundamental experiment of crossing *Nicotiana rustica* with *N. paniculata.*

Important observations concerning the morphology of the flower and provisions for fertilization in the Compositae were published by an Italian, Count Lavola, in the year 1764 in his *Discorso della irritabilita d'alcuni fiori nuovamente scoperta,* etc. Much later, in 1793, Conrad Sprengel's celebrated work appeared: *Das endekte Geheimness der Nature im Bau und in der Befruchtung der Blumen* ("The discovered secret of Nature in the construction and fertilization of flowers"). It is rich in interesting and exact observations concerning the relation between the form of the flower and insect visitors. These experiments appeared as a continuation and further development of Koelreuter's investigations which he had made public more than thirty years before. At that time they were given but little attention by scientists.

Toward the end of the eighteenth century another man appeared whose works concerning fertilization and hybridization have become of special importance, namely, Thomas Andrew Knight, the celebrated fruit and vegetable grower. Through the successful endeavors of the animal breeders, who tried to improve the domestic animals by crossing the different races, he came to ask the question if it were not possible by crossing races to obtain improved kinds of useful plants. Without knowing anything of Koelreuter he began his experiments with fruit trees and in 1787 with peas, by means of which he could get definite results much sooner. The progeny of his crosses between the races of peas made extraordinary gains in vigor and fertility. As early as 1799 Knight states "that nature intended that sexual intercourse should take place between neighboring plants of the species" (*Philos. Transactions,*

1799, Part II, page 202). He based this sentence upon his experiments with individual and race crosses, especially in the genus *Pisum*.

The important facts of fertilization had therefore been correctly recognized and made public at the end of the eighteenth century by several investigators. Koelreuter had discovered the importance of insects in the fertilization of plants; Conrad Sprengel had followed out in all their details the relationships between flowers and insects; Thomas A. Knight had demonstrated the advantages of crossing races. Although a few recognized the value of these facts this knowledge was not generally accepted and made a part of science. The real scientists followed the way opened to them by Linnaeus; they considered of most importance the recognition of species and their correct placing in genera and the higher systematic orders. But it is judging the spirit and endeavors of the time too superficially and too one-sidedly to believe that the species dogma crippled the free movement of thought.

The belief of the constancy of species was at that time not especially firmly grounded. Linnaeus himself, as we have before mentioned, was guilty of grave heresies against the doctrine of absolute and constant species. Medikus, the friend of Koelreuter, regarded as of no importance the question whether a genus comprised three different species or one species with three varieties. Duchesne, who introduced the conception of races into botany, was certainly far from believing in the constancy of species. Only the lack of a better understanding of known phenomena and facts prevented these and certainly many other men from taking a firm stand against the doctrine of the constancy of species. One would therefore be wrong in charging to doctrinal bigotry the fact that the discoveries of Koelreuter, Sprengel and Knight were so little regarded and understood. The truth is that these discoveries did not fit into

the idea of nature then current, for they could not be reconciled with then known facts and therefore were disregarded.

III. 1800—1825.

In 1800 there appeared J. E. Smith's *Flora Britannica*, a work in which for the first time two spontaneous hybrids between native species were introduced as parts of a European flora and expressed as *"β var. hybrida."*

To be sure, the hybrid *Verbascum thapsus* × *nigrum* was observed only in gardens and could therefore be classed with similar hybrids recorded by Linnaeus and Koelreuter. *Verbascum pulverulentum* × *nigrum* was, on the other hand, a true, spontaneous hybrid, originating in the wilds.

In 1809 there followed communications by Villars, concerning spontaneous hybrid *Gentians* (*Roem. Coll. Bot.*, p. 186), and in the following year a paper by J. D. Hoppe concerning a hybrid *Aconitum* (*Neues bot. Taschenbuch*, 1810, p. 217). The first clear and detailed description of the circumstances under which a wild-growing hybrid was observed, was given in 1823 by Guillemin and Dumas in their "Observations sur l'hybridité des plantes" (*Mém. Paris Soc, hist. nat.*, I, 79-92). As regards French achievements at this time in the realm of hybrids there may be mentioned the experiments of Sageret which were begun before 1820. From Bellardi there appeared in 1809 an article (*Saggio Botanico-Georgico*) in which were described several experiments on hybridization with cereals.

The disputes of the German scientists over the sexuality of plants and hybridization are noteworthy for their extraordinary fruitlessness. Schelver critically reviewed the theory of the sexuality of plants but did not find it sufficiently well grounded; which decision, however, was only possible because he cast aside Koelreuter's investigations and de-

ductions as unworthy of belief. Henschel further strengthened the belief in the non-sexuality of plants in that he tried to replace a total lack of uprightness and sense of truth by a skilful sophistry and by the overwhelming shamelessness of his assertions. The defense of the sexual theory was taken up mainly by L. Chr. Treviranus, who demonstrated in a strictly scientific way the facts in the case. But his laborious manner of writing could not compare with the unscrupulous arguments of Henschel, so that the latter, who was favored by those in power, seemed for a time to be the conqueror in this war of opinions. The quarrel partly turned on the truthfulness and trustworthiness of Koelreuter's assertions. Nothing would have been easier than that Treviranus, who believed in Koelreuter, should have repeated several of his experiments, which, after the way had once been shown, would certainly not have been too difficult for the superintendent of a botanical garden. Instead of that he allowed Henschel, who really made some experiments in hybridization, to surpass him even in this field. Henschel used these experiments for swindling instead of for earnest investigations. It would be an insult to the dignity of science to waste even a word over the assertions of Henschel. It is sufficient, as Godron has done, to mention Henschel's pretended hybrid between *Spinacia oleracea* and *Pinus strobus* to show the justness of this contempt. Finally, about the year 1819, the desire for reliable experiments in hybridization became more general.

While German science during the first quarter of the nineteenth century could show only unimportant or ignominious performances in the field of hybridization, English gardeners and flower-lovers, at the same time, made a great number of enlightening experiments. To be sure these were mainly in gardening but were also of scientific interest. Knight continued his crosses between different races or nearly related kinds of fruits and vegetables.

About 1808 R. J. Gowen, gardener of Lord Carnarvon of Highclare, and the English priest W. Herbert, began their long series of successful experiments in crossing plants, principally between species of *Erica, Rhododendron, Gladiolus* and *Hippeastrum.* A gardener, Thomas Milne, obtained the first hybrid in *Passiflora.* Robert Sweet busied himself with crossing species of *Pelargonium* and took great pains to establish the many varieties of *Pelargonium* raised by other plant-lovers and gardeners. Sweet's work, *Geraniaceae,* is perhaps the most comprehensive writing on hybridization which appeared during the first quarter of the nineteenth century. However, until now, not a single investigator in this field has paid any attention to it.

On the other hand, a sensation was aroused by the lively exchange of ideas between Knight and Herbert in the meetings and publications of the London Horticultural Society. Knight maintained that the hybrids between specifically distinct types were always sterile; fertile hybrids were always the result of crossing varieties. He said the fertility of a hybrid between two types, heretofore held to be different species, would, in spite of their dissimilarity, show that these were only varieties of a single species. (*Transactions Hort. Soc.,* London, IV, 367-373.) Herbert, on the other hand, had found that hybrids between manifestly different species are often fruitful; but he agreed with Knight in acknowledging that the possibility of producing a fertile hybrid or even a fertile cross between two plants, showed their original genetic relationship. He held that at one time there were only generic and family types which probably may not have exactly agreed with the present divisions of the botanical system. From these original types he derived the modern species not like Linnaeus, through hybridization, but like Lamarck and G. R. Treviranus, through "differentiation."[2]

[2] "I suspect that in the early periods of the world, there existed only the

The kernel of the whole dispute was the question of whether there existed a sharp and immovable boundary between fertility and infertility of the hybrids; but behind this question there was really a second, namely, whether there existed a sharp boundary between species and varieties. Species-hybrids should be sterile, variety-crosses fruitful. The Knight-Herbert discussion was a prologue to the later Cuvier-Geoffroy quarrel, which was played upon a much larger stage and with more comprehensive knowledge on the part of the actors.

IV. 1826—1850.

In England, the year 1825 continued to make additions to the history of hybrids. The gardeners continued to produce numerous hybrids and through Sweet, G. Don, Paxton, Lindley, Herbert and others, much has become known concerning the results of these crossings. The communications of Herbert, in an appendix to his work on the *Amaryllidaceae* and in a special essay in Vol. II of the *Journal of the Horticultural Society,* are most comprehensive. These papers were founded upon his own experience and that of others. His views are in general clear and reliable, even though not always complete enough for the strictly scientific investigator. At any rate, he has done more for the furtherance of our knowledge of hybrids than any other writer during the last half of the nineteenth century. In contrast to Koelreuter, Gaertner, and many later writers, he made his experiments almost entirely upon long-lived perennial plants.

During the period between 1825 and 1850 France can show especial achievements in hybridization. Several noteworthy papers we owe to Sageret and Lecoq, and several

distinct genera of plants, or heads of families, not however, exactly according to the present divisions of botanists." (*Trans. Hort. Soc.,* London, IV, 16.) Later, Herbert compared the origin of species from a common parent form with the development of the languages from a few original languages. (*Amaryllidaceæ,* p. 339.)

gardeners made observations upon accidental or intentionally made hybrids. In 1844 there appeared Godron's first work upon hybridity in the plant kingdom, with descriptions of some hybrids found growing wild.

More noteworthy are the German works during this period, although in reality they only sufficed to expose Henschel's deceptions and to substantiate to the highest extent Koelreuter's observations. By the agitation of Link, the Berlin Academy of Sciences in 1819 and again in 1822 offered a prize for an answer to the question: "Can hybrids be formed in the plant kingdom?" Finally there was sent in a paper by A. F. Wiegmann, to whom in 1826 half the prize was given. This work was published in 1828 under the title: *Ueber Bastarderzeugung im Pflanzenreiche.* The author agreed entirely with the views of Koelreuter and Conrad Sprengel. He made a number of unquestionable hybrids, besides some variations which he considered hybrids, the cause of whose origin has not even to-day been determined. In the years following there were published several papers concerning successful crossing; for example, those of Christian Lehmann.

Of greater importance are the investigations of Carl Friedrich Gaertner (May 1, 1772 to Sept. 1, 1850). The first published work of this hybridizer was, to be sure, very presumptious. He had carefully studied the writings of Koelreuter and in the year 1825 made a great number of experiments in pollenization. He now wrote an essay on hybrid fertilization (*Naturw. Abh.,* Tübingen, I, 1), in which he pretended to be an experienced hybridizer and gave the results of his pollinations, most of which, as was later discovered, were only apparently successful. This essay was translated into French, and was undeservedly published in *Ann. sc. natur.,* X, 113-148 (1827). The tone of ripened experience which Gaertner adopted misled many to believe in his supposed results and in addition the sup-

posedly successful fertilizations were confused with the successful ones. This paper therefore became the source of great mistakes, though not entirely through the fault of the author. Later Gaertner was able to report an increasing number of actually obtained hybrids (published in *Flora*), and he continued his crossings through several decades. In number of experiments he has probably not been surpassed by any other hybridizer. His book: *Versuche und Beobachtungen über die Bastarderzeugung im Pflanzenreiche*, comprises the essential features of two of the author's papers which were submitted in competition for the prizes offered by the Kgl. Niederl. Akademie der Wissenschaften in 1830 and 1836,[3] together with communications offered in his scattered essays. It might be regarded as a working over of all the results obtained by his various experiments. Unfortunately, this very comprehensive work is extraordinarily dull; it is therefore on the one hand not well enough known and on the other its value is frequently overestimated. It is difficult to obtain a decided opinion upon the trustworthiness of the views expressed because the book contains numberless inaccuracies and contradictions. A careful, special study has convinced me that the mistakes in Gaertner's work were caused by an extraordinary lack of ability as a writer and his incapability to arrange in order his observations and facts. According to all appearances the author used his scattered notes concerning his observations about hybrids without ever reporting the deficiencies and incompleteness of the first investigations, even though later experiments showed entirely different results. Only thus can it be explained that the statements so often contradict each other. Among others, the remarks concerning the *Passiflora* hybrids on pages 241, 242, 288, 332 and 337 are characteristic. These

[3] The paper published in the Dutch language is little known and I have not yet seen it.

show how little Gaertner was able clearly to set forth a simple fact. Such sentences, in which the cause of the contradicting assertions can be seen, give the key to the understanding of the means of origin of many other wrong statements. The material which Gaertner worked over is confined almost exclusively within the lines laid down by Koelreuter.

Even though Gaertner's work is a well-filled revision of hybridization studies, one must never forget that it should be used with great caution and critical circumspection. More important and of greater service are Gaertner's investigations concerning the normal processes of fertilization.

Another branch of hybrid investigation reached conspicuous importance in Germany during the second quarter of the nineteenth century. Several able botanists had directed their attention about 1825 toward the hybrids found in a wild state. A. Braun, Wallroth, Zuccarini, G. W. F. Meyer, Ziz, W. D. J. Koch, and others, had recognized a number of spontaneous hybrids. Schiede, who had himself actively taken part in these investigations, collected all hitherto known facts on this subject. His little paper: "*De plantis hybridis sponte natis,*" appeared in 1825 and should be regarded as a forerunner in the study of hybrids in nature. Lasch and L. Reichenbach soon added new examples to the known cases of spontaneous hybrids, so that by 1832 A. P. de Candolle was able, in his *Physiol. végét.,* to complete Schiede's list. Especially valuable were later the careful investigations of C. Nägeli concerning hybrid *Cirsiums.* Fr. Wimmer, in connection with several friends (Krause, Wichura and Siegert), investigated with great success the hybrids in the Silesian flora. In spite of many mistakes in details correct knowledge concerning spontaneous hybrids made rapid progress. The conservative florists, to be sure, wished to know nothing of the many

hybrids, also many others, zealous for the doctrine of the constancy of species (for example Hornschuch), were against accepting so many because they were more inclined to believe in variations and intermediate forms.

V. 1851—1880.

The year 1850 marks a natural division in the history of hybrids. The death of the two most prominent hybridists in the first half of the century (Herbert in 1847 and Gaertner in 1850) on the one hand, the appearance of new investigators on the other, would have been sufficient to show a dividing line, even if there had not at the same time been developed a new tendency in the aims and endeavors of the investigators of hybrids. The first incentive to a lively discussion of the hybrid question came from J. F. Klotzsch. In a paper (*Verh. Kgl. Preuss. Akad.*, Berlin, 1854, pp. 535-562) he stated, among other assertions, that hybrid pollen is always sterile, that hybrids can never be fertilized with their own pollen, or with that of a third species, but only with the pollen of the parent form. In opposition to the experiences of Koelreuter, Gaertner, Herbert and numerous gardeners, this assertion was, in truth, more than bold. The first person who positively opposed this statement was E. Regel, who at that time had already had an extensive experience in the growing of hybrid *Gesneraceae*. Even though his crosses were made for gardening purposes, he did not lose sight of the scientific side of the question. Some of his most convincing proofs were taken from the genus *Begonia*, which Klotzsch had chosen for his especial study.

The usefulness of the discussion consisted principally in bringing to light a number of facts which otherwise would have remained entirely unknown. Moreover, for any unprejudiced person there could be no doubt in this case that Regel was entirely right.

Almost at the same time there developed in France another quarrel; namely, that concerning the *Aegilops* question. It was A. Godron who first destroyed the fanciful notions concerning the transformation of *Aegilops* into *Triticum,* through the origin of the artificial hybrid *Aegilops triticoides,* and who also proved by experiment that *Aegilops speltaeformis* came true to seed. A. Jordan's criticism of Godron's experiments, which is of value even at the present time, resulted in Godron and others (Grönland and Regel) endeavoring to establish the facts through repeated experiments in all directions.

The Klotzsch-Regel and Jordan-Godron discussions gave the incentive to further important investigations. On Jan. 30, 1860, the Paris Academy of Sciences decided to make use of a prize, which had been placed at its disposal, and to award it in the year 1862 for the best paper on "Hybridization in the Plant Kingdom." The Academy especially hoped to draw attention to three points, namely: the fertility or unfertility of hybrids; the cause of sterility, whether due to the pollen or the female organs; and finally the constancy of fertile hybrids through reproduction by seeds. Apparently the period of three summers which lay between the offering and the awarding of the prize, was much too short to begin and finish important new investigations. The Academy could only hope that the prize would be an incentive to a zealous continuation on the part of such men as had already busied themselves for some time with hybridization experiments, and to the publishing of the results of their endeavors. Two papers were handed in which were founded upon numerous experiments, the authors being Chas. Naudin and D. A. Godron. For sufficient reasons the Academy declared the work of Naudin to be the better and awarded him the prize, giving the work of Godron only honorable mention. The criticism of Duchartre on the decision of the Academy concerning God-

ron's work was not entirely without foundation. There is no doubt that in many respects Godron worked more carefully and thoroughly than his opponent. If one gives this scientific achievement a careful scrutiny it will be found surprising in one respect. In this prize paper Godron did not include all his former experiments, but considering everything the two experimenters described about thirty long series of experiments and noteworthy single experiments, to which must be added several incomplete observations and communications on facts long known. If one contrasts therewith the great mass of material which the investigations of Koelreuter, Herbert and Gaertner, not to speak of others, have furnished; then the material used by the two French investigators, though very useful, was apparently insufficient for a comprehensive and in some measure finished opinion on the subject.

Godron, as well as Naudin, founded his views concerning hybridization almost entirely upon his own investigations; the incomparably larger amount of his own and foreign experiences which Gaertner used in writing his work, was given practically no consideration. Moreover the two contestants had formed different ideas concerning the purpose of the prize. Naudin declared, clearly and decidedly, that in the meaning of Cuvier's theory there were no sharply defined species. "There is no qualitative difference between species, races and varieties; in searching for it one is pursuing a chimera. The three things are one, and the words by which one pretends to distinguish them, indicate only the degree of contrast between the comparative forms." (Cuvier, in *Ann. Sc. Nat. Bot.*, 4 ser., XIX, 201.) Naudin therefore saw no ground for considering nearly related but well characterized forms as anything else than distinct species. He found that there existed fertile and unfertile hybrids, but that the descendants of the fertile

hybrids more or less rapidly reverted to the parent type. Upon this last point Naudin placed the greatest weight.

Godron held fast to Cuvier's idea of species and was then still of the opinion that all hybrids between true species were entirely sterile[4] but were capable of being fertilized by the pollen of the parent forms or by that of another species. He held that through such recrossing there originated the richness of forms in the progeny of hybrids; that in general, the new forms would, in case they were protected from further crossing, be fixed and come true to seed. Fertile hybrids, in the first generation, isolated from their parent and related species, were not considered by Godron to be true hybrids between species, but were "blendings" whose parent forms were only races of one and the same species. Godron's entire view-point was governed by his experiments with the hybrids between *Aegilops* and *Triticum,* while Naudin was guided preferably by his observations on the *Solanaceae* and *Cucurbitaceae.* These two works are the sources from which numerous later botanical writers drew their views concerning plant hybrids; but no unprejudiced person will deny that in true worth they are conspicuously behind the works of Gaertner. The discouraging dullness and terrible confusion of the German investigator's presentation makes a study of this work, which is so rich in facts, very disagreeable; while the two Frenchmen developed their views in short, clear essays written in a fascinating manner. Their works, especially Naudin's, won in importance because the award by the French Academy stamped them as classics. The circumstance that the two authors contradicted each other in essential points should be regarded as fortunate for science, for otherwise their assertions would for a long time have been regarded as unassailable. Moreover, both Naudin and Godron continued their experiments so that their

[4] In his later articles Godron did not adhere to this mistaken opinion.

services to the science of hybridization are by no means to be found only in their competitive essays.

The next most important work concerning hybrid plants appeared in 1865. It was Max Wichura's *Die Bastardbefruchtung im Pflanzenreich, erläutert an den Bastarden der Weiden.* The numerous and painstaking experiments made by the author himself, are restricted to the genus *Salix,* in which he combined as many as six species into a single compound hybrid. In contrast to Godron, he confirmed the views of Koelreuter, Herbert, Gaertner, Naudin and others, that hybrids are frequently fertile to their own pollen, and also found, in contrast to Naudin, the progeny of hybrid willows to be constant. He thereby refuted the mistakes of his two nearest predecessors, whose works, moreover, he seems not to have known at all.

During the years 1865 and 1866 there appeared several noteworthy essays by C. Nägeli concerning the formation of hybrids in the plant kingdom. (*Sitzungsber. Akad. München, Math.-phys. Cl.*, 1865, II, 395; 1866, I, 71 ff., 190 ff.). Nägeli did not himself make any experiments in hybridization but he carefully observed numerous wild-growing hybrids. He was much more familiar with the literature of the subject than was Naudin, Godron or Wichura. For example, he deducted from the given facts in Gaertner's works the consequent conclusions. It was first through Nägeli that science was able to make use of the fruits won by Gaertner's experiments. To be sure Nägeli acquired some of Gaertner's tendency to doctrinarian views and the presentation of general theoretical dogma. Especially is this true in regard to Nägeli's theory of *Bastardirungsäquivalent,* in which he seeks to express numerically the degree of the resemblance of the hybrid descendants with the parent forms. He takes into consideration first, the part which each parent form takes in the production; second, the typical strength of these parent

forms, counting the number of generations needed to bring about the transformation. The fluctuation of characters, which is so common among the progeny of hybrids, as well as the tendency of reversion to the parent form, is sufficient to overthrow any such hypotheses and calculations. There is just as little support for the theory for the different influences of the male and female elements upon the characters of hybrids. Nägeli especially emphasizes the fact that it is immaterial for the systematic characters of the hybrids which of the parent species was the male or the female progenitor. The confidence which he put in Gaertner's statements would, by means of a sufficient number of his own experiments, have put him upon the right track. It is without doubt through Nägeli, that the theory of hybrids in the plant kingdom was for the first time completely demonstrated in an unprejudiced and connected manner. The scientific service of these works must be credited with great importance; they have been the source from which the text-books (like that of Sachs) and most of the later theoretical views concerning hybrid plants have been derived.

It is only necessary here to call briefly to mind the importance of Darwin's work on the doctrine of hybridization. To be sure Darwin's own experiments extended only in a few cases to crosses between species, but with great success he connected his investigations with Knight's experiences in the behavior of crosses between individuals and races. Moreover his experiments in the artificial fertilization of heterostyle species are extraordinarily useful.

Of recent scientific experiments in crossing Robert Caspary's hybridizations in the *Nymphaceae,* G. Mendel's with *Phaseolus* and *Hieracium,* D. A. Godron's with *Datura, Aegilops, Triticum* and *Papaver,* have to be regarded as especially instructive. Godron's series of experiments with *Datura* hybrids may be considered as the most prominent.

Through these experiments the fact was established, that from fertile hybrids having highly variable progeny, there can be produced, in the course of a few generations, races having mixed characters and coming true to seed. For new actual experiments with the characters of hybrids we have to thank Godron more than any other investigator of the nineteenth century.

The numerous crosses which were carried out by Gaertner during the last ten years have advanced the scientific knowledge of hybrids comparatively little. But of great interest are the hybrids of *Sarracenia*, *Nepenthes*, and numerous orchids produced by the English breeders, Seden, Dominy and others. Kellermann has communicated good observations concerning the hybrid *Araceae* raised by him.

Since 1830 the study of wild-growing hybrids has made important progress. To be sure the unprofessional have worked in the field as zealously as the professional; a careful examination of their views is therefore urgently requested; also because most of the florists have known little more to tell than the recognizable characters of the hybrids observed by them. The most numerous and important communications concerning wild-growing hybrids have been offered by Fr. Schultz, Timbal-Lagrave, Grenier, A. Kerner, Wirtgen, Michalet, Ritschl, Beckhaus, P. Ascherson, R. von Uechtritz, J. Schmalhausen, C. Haussknecht and V. von Borbás, not to mention numerous local florists.[5]

Through Fr. Schultz the investigations were often led into false paths, in that this erudite botanist held, with a certain fanaticism, the view that each hybrid combination appeared in two forms, according to which one of the parent species had yielded the pollen. He regarded it to be his duty, when finding a hybrid, to recognize from its characters which of the parent species had been the seed parent and which had yielded the pollen. His example

[5] Nägeli, Godron, Wimmer and others have already been named.

misled others to similar mistakes. Only gradually has this trifling been given up. On the other hand there has recently come to the front a tendency to use hybrids as material for the manufacture of new names. Nevertheless our knowledge of spontaneous hybrids has been considerably widened through the observations of the florists. One of the newest pertinent treatises; namely, that of J. Schmalhausen (*Bot. Zeit.*, 1875, pp. 520, 534), indicates how in the future the study of spontaneous hybrids may be of real use to science.

There was published by K. A. Kenniger in 1879 in the 62d volume of *Flora*, a compilation of the spontaneous hybrids found up to that time in Germany and Austria; remarks upon these by Otto Kuntze are to be found in Vol. LXIII, No. 19.

If one bears in mind the knowledge concerning hybrids in its principle features, he can take from it a decided lesson: *No greater mistake can be made than to try to generalize from a few single experiments.* Without doubt one can lay down well founded rules concerning the general behavior of hybrids, but one must not forget that for each of these rules more or less numerous exceptions will be found. In contrast to the unbending laws which rule inanimate nature, organisms show a certain freedom in their life phenomena, an unrestrained flexibility. Physiology must keep this fact in mind if it wishes to know and investigate with an unclouded view the transformations of which the plant form is capable under the influence of inner and outer forces.

WILHELM OBERS FOCKE.

BREMEN, GERMANY.

THE PRINCIPLE OF RELATIVITY AS A PHASE IN THE DEVELOPMENT OF SCIENCE.

THE principle of relativity made its appearance with great pretensions, and upset not a little the scientific world by its claim to antiquate the traditionally classical basis of physics, of astronomy, of mathematics, and of the other natural sciences. It affects especially the commonly accepted theory of the ether, and even the current views of space and time, which have hitherto proved serviceable. The entire realm of science was almost panic stricken for scientists seemed to have lost the *terra firma* under their feet; they felt as if they were sinking into a bottomless abyss and were left without a standing place in the whirl of a universal flux. Physicists of former date might take the movement for a joke, and many conservative thinkers find a good deal of humor in it, but the relativists are quite serious and are aware of the gravity of the consequences of their subversive work.

However, the new conception sailing under the flag of the principle of relativity which has been so noisily advanced to replace the old notions, does not prove quite satisfactory and presents too many difficulties to be acceptable to the average mind. It consists mainly of contradictory and mystifying statements commonly called "the paradoxes of relativity," and these statements have been praised or ridiculed, accepted or rejected, by enthusiastic adherents or obdurate adversaries, so that we have a state of things not unlike the rise of a new religious creed as it sets out to conquer the world. The names of Einstein, Lorentz, Minkowski, are the stars of first magnitude among the founders of the new world-conception. Their arguments, mathe-

UMI

matically well excogitated and worked out with subtile exactness, seem to carry everything before them, and we are not prepared to say that their contentions are wrong. Their propositions decidedly contain truths of great importance, referring mainly to calculations of minute precision in complicated phenomena. Yet common sense rebels against them and would not be convinced. *Prima facie* the new doctrine seems *ingeniosius quam verius*; it is ingeniously contrived but there is a hitch in it.

In former articles[1] we have shown that the paradoxes have merely an appearance of contradictoriness; they can be explained as slightly misstated conclusions and so the relativists could have avoided mystification. If physicists had borne in mind that as a matter of course all determinations and calculations of measurement require a reference point which remains unaltered in its relations to other points within the field of observation and is assumed to be stable, the problem would never have arisen. The new cases of unstable reference points which make their first appearance in 1727 with Bradley's investigations would simply have demanded a corrective without in the least upsetting the traditional view, and this will after all be the outcome of the new movement. It is to be anticipated that in the long run the paradoxical features of relativism will disappear, and when the results of the new propositions will be formulated without ado in sober consistency, it will be found that they only modify the old traditional physics and astronomy under certain specially complicated circumstances, particularly when the place of an observer while making his observations possesses a motion of its own affecting the motions under observation.

It almost seems as if the entire proposition of the principle of relativity might as well have been abandoned be-

[1] "The Principle of Relativity," *Monist*, XXII, 188, and "The Philosophy of Relativity," *Monist*, XXII, 540.

cause the relativity of motion as well as of space, the field of motion, was not unknown to earlier physicists. Is not relativity the nature of space? Denunciations to the effect that earlier physicists and astronomers had believed in an absolute space are really a misconstruction of their views, for what Newton called absolute space did not involve a denial of the conditions about which the relativists have troubled their minds.

As a symptom of sobering down, we mention an article of Edward V. Huntington which appeared in the *Philosophical Magazine* for April, 1912, under the title "A New Approach to the Theory of Relativity," pages 494 to 513. After explaining experiments with synchronized clocks, Professor Huntington says on page 507 as follows:

"These are the famous paradoxes of the theory of relativity which are often cited as proof of the assertion that the theory of relativity is incompatible with our ordinary ideas of time and space, but which here appear as necessary consequences of perfectly natural and reasonable conventions for setting clocks and laying out coordinates."

Further Professor Huntington takes away the mystery from some other propositions of the relativity principle. He concludes that "thus all the transformation equations used in theorem 1, are obtained by an entirely natural and elementary method."

The question then arises, Has the appearance of the principle of relativity done nothing to promote science, or has it even been a mistake? And we say in answer that the principle of relativity might have approached its problem in a more conservative way simply by bearing in mind that former physicists were perfectly aware of the fact that whenever they made measurements they laid down a point of reference for their calculations. This reference point must share the motion of the phenomena observed, or at least the difference must (for the purpose in view)

be a negligible factor. We know very well, and all scientists of former generations also knew, that the stability of our reference point is a fiction, but without making this fiction our calculations would sink into the bottomless.

While the geometer calculates distances on earth, he knows very well that the reference point from which he starts is not absolutely stable but moves around the sun with the entire earth, including the objects and the distances to be measured. When astronomers took measurements of the stars they knew very well that their own telescopes were moving along through space with the velocity of the earth under their feet, but for the purpose in view this movement was a negligible factor. Both physicists and astronomers of former times took it as a matter of course that we know of no point of absolute rest, that everything is relative, and that thus there is no absolute space in which their systems of measurement held a definite and invariable position. In this sense the principle of relativity is not quite so new as its enthusiastic adherents frequently claim. The contradictions and paradoxes are merely on the surface, and there is little hope of replacing the old orthodox mechanics which will even in the times to come hold good for all the usual commonplace fields of observation.

For all that, we do not mean to belittle the principle of relativity; the new method has its advantages, and in certain spheres it will find its application. What the relativists have accomplished may be comparable to the invention of a micrometer which proves very useful in making minute measurements hopelessly out of reach of the coarser instruments used in daily practical life. But as the micrometer will not abolish the usefulness of the yardstick, so relativist considerations will not upset the commonplace view of traditional mechanics. There is no contradiction between the two, if only we rightly understand the philo-

sophical basis of the ordinary methods of measurement with their indispensable fiction of laying down a reference point and ignoring the negligible factors of changes that take place while observations are being made, changes that may affect size, time and distance. The need of an indispensable reference point, the assumption of which is always a fiction made for the purpose in view, will be felt no less in the more complicated considerations which have prompted the rise of the new mechanics of the relativists.

In order to satisfy the demand of the conditions to which relativists have devoted their special attention, we have simply to bear in mind that the assumption of reference points is absolutely indispensable for any kind of measurement.

We may therefore say that the relativists have proposed their new theory as new in neglect of comprehending the philosophical basis of the science of measurements. We may grant that in the traditional treatment of kindred problems it was perhaps ignored, yet we trust that it was tacitly assumed.

The principle of relativity is therefore not useless, for it is serviceable in a field where more complicated interrelations have to be observed; but if the relativists dig deeper they will find common ground with their predecessors in the philosophical basis of the theory of measurement. As to the ether we must consider how little we know about its nature, and it seems premature either flatly to deny its existence, or to affirm doubtful qualities of it, or to make bold *a priori* statements as to its motions with reference to the motions of matter. Here experiments alone, like those made by Professor Michelson, will be decisive. Finally whatever difficulties may still present themselves, we may be assured that all of them will find a satisfactory solution without upsetting the foundations of our scientific world-conception. EDITOR.

THE BOOKS OF PRIMEVAL HISTORY.

[In former numbers of *The Monist* we have published the following philosophical poems of the late Major J. W. Powell: "The Soul," April, 1895; "Becoming," July, 1911; and this third contribution glorying in the ancient records of geology, of the sites of ruined cities and the graves of primitive man, exhibits the same enthusiasm for the results of scientific research as did the former poems for philosophical subjects. We have selected this poem, here published for the first time, from the manuscripts which the author shortly before his death entrusted to the editor.—ED.]

THE STONE BOOK.

The history of primal man is found
In doomsday book of generations dead—
The rock-leaved bible called Geology,
With pages graved in elemental strife,
Where every fossil letter cost a life.

The primal arts were born in every land,
For widely scattered o'er all lands are found
Stone tomahawk and spear and knife and dart—
The cruder vestiges of man's first art.

The culture first expressed in tools of flint
Began in every land, and long ago—
A moment, reckoned right in scale of time,
The geologic dial used by sage,
But told in years of man, an unknown age.

That history in stone, spread o'er the earth,
Whose pagination is in fossil forms,
Records a meager tale of primal man—
That being shared by every lowly brute,
Without the trace of higher attribute.

The time-bleached casket erst that held the brain
Reveals but ill the mind of early man,
For nobler life of proud humanity
Is not expressed in framework osseous
Which petrifies in beds of ooze and clay,
To be exhumed for cabinet display.

Fools dig for bones and measure them by rule,
(Their art ycleped as "anthropology,")
And vainly deem they resurrect the man
In empty cranium of ancient mole
And find a "dolichocephalic" soul.

These primal men of stone-book record lived
In forest, round the sheltered bays of sea,
On shore where wild bird's flight to reedy isle
Was mirrored clear in quiet woodland lake,
On bank where fishes played in purling brook,
Near spring where flower bloomed in quiet nook.

The Eden fair of stone-book men was large.
They could not wander out through polar zones,
For, walled with ice, their Eden was enclosed.
Between these frozen lands, where summer's sun
The verdant hills and waving meadows warmed,
Their garden stretched through all the zones of life.
So all the lands to primal men gave birth—
The universal denizens of earth.

UMI

Before they learned stone knives to fashion fair,
Before they learned shell beads and plumes to flaunt,
To build of bough and bark and reed and stone
Their shelters rude from wind and drenching storm,
These men had wandered over every vale
And made their homes in every quiet dale.

These sylvan men and dusky mates of old,
In tribes whose bonds were streams of kindred blood
And cords of love entwined of marriage ties,
Were scattered everywhere throughout the earth
Before the human tongue was skilled in speech,
Before the race had learned the trade of kings
And force of laws and majesty of courts.
They lived in plenty with the crudest arts,
And high emotions kindled not their hearts.

But primal man expressed his thought in art,
And fashioned stocks and stones for simple use,
And slow evolved a lore of mythic life,
And speech for mild or harsh exchange of thought,
Invented social life for help and peace,
And sports for wold illumed by fagot light
That cleft the shadows dense of forest night.

From modern culture back to primal state
These arts are traced in sure converging lines,
The lore becoming more a mythic tale,
The tongue more babbling in simplicity,
The institutions ever found more crude,
The sports more childish in their simple glee—
To trace all this with just fidelity
Is task of truer anthropology.

UMI

Song.

Book of the rocks adamantine,
The drama of ocean and land,
Mountain and forest and prairie
And fountain and cataract grand,
Eons of change is your story
While islands of ocean were planned.

Book of the ages unnumbered,
With record of flood and of fire,
Headlands engulfed by the waters,
And seas raging high in their ire,
Eons of earthquakes your story
And mountains on funeral pyre.

Book of biology primal,
Of lives on diversified plan
Blooming in Edens of verdure
Or roaming by kindred and clan,
Eons of life is your story,
With postscript for primitive man.

THE RUIN BOOK.

The vestiges of early homes are found
In wild confusion scattered o'er the earth,
On sites of thorps no longer used by man,
All marked with relics rude and strange and waste,
As tools of flint and potsherds scattered wide,
And mealing stones, and bowls of steatite,
And many a needle made of bone or horn,
And kitchen fragments now in heaps forlorn.

For knife and spear and arrowhead man wrought
The torrent-fashioned boulder of the stream
And dornick quarried from the bank or scaur,
And deftly wrought the stone to cutting edge
With blow of granite hammer wrenched from cliff,
Awhile the spalls were scattered o'er the glebe
With reject forms that fitted not the plan
Of primal, patient, toiling artisan.

Anon the failures found at quarry ledge
Are made to tell of "paleolithic" man;
The finished tools of village site give proof
Of "neolithic" art and puzzled sage.
So, wandering by river bank at work,
The sylvan man belongs to primal age;
But, home returned, is classed in higher stage;
And two mysterious groups of men are found
Whose occult arts bestrew the modern ground.

In humid lands clear tarns reflect the sky,
With sapphire depths and drifting clouds of gray,
While reeds and waterlilies fringe the shore,
Whose creeping roots reluctant share the sands
With driven boles of ash or oak or pine—
Foundation weird of ancient palafitte,
The clustered dwellings reared above the wave,
Where spearman pierced the trout with antler glave.

Lacustrian dwellings now in ruins lie
Beneath the storm-fed, wave-washed sands of time,
To bury many a work of primal art
That now a tale of ancient times impart.

In arid lands, where cliffs and ledges stretch
Athwart the opalescent desert wild,

High mesas stand, as broad foundation built
For pueblo homes in centuries agone,
Whose ruins tell the tale of culture's dawn.

Where stalked the boasting chief the wolf now prowls;
Where danced the tawny maid the raven hops;
Where children nude disported in the sand
The badger digs a home for owl and snake;
In ancient tom-tom halls the bats now screech
And gliding lizard turns its agile head
To gaze on squirrel sporting o'er the dead.

Eternal rivers roll through high plateaus
And cut their channels deep with flinty saws,
Till canyon walls o'erhang the roaring wave,
With buttressed shelves and adamantine floors
And stairways grand to storied halls of cliff,
All carved by artist storms for homes of men,
Primeval wanderers in canyon glen.

These homes have crumbled, cliffs have fallen low,
And stairways grand have yielded unto flood,
And primal arts are buried deep in sand,
To be exhumed for lore of modern land.

In geologic time the earth was rent,
And blast from subterranean furnace poured
A storm of dust athwart the firmament,
In streams pulverulent of pumice stone,
Which fell to earth, awhile new mountains rose,
And round whose summits purple clouds repose.

As storms are marshalled under banner red
Along the craggy battle-field of mount,
The cohorts plunge adown the steep defile

In torrent columns over pumice slope
And open canyon lanes to valley low,
While chalky cliffs are left to mark the way
Of mighty rivers rolling on for aye.

High up these cliffs the ancient man made home
In lodges excavate with maul of trap:
Deep chambers, carved in pumice rock of white—
The cavate dwelling strange of primal knight.

But patient time, who builds the continents
And scatters them again o'er ocean floor,
But smiles at tufa cliffs, and lays them low
In ruined heaps, where buried arts now show.

The vales and plains that gather waters sweet
To feed the crystal streams that pour their floods
In midland sea that rocked the cradle soft
Of early culture, now historical;
The desert valley fed by tawny Nile;
The bulbul vales of Tigris and Euphrate;
The river lands of "Ind and Far Cathay";
The table lands becrowned with mountains huge,
Are all the sites of ancient cities dead,
Whose walls and turrets now are buried deep
And kings and prophets tombed in final sleep.

Then comes the story of Vesuvius,
With cities buried under fiery flood
For many centuries of deep repose.
The all-destroying element of fire,
Its lust for slaughter sate with sacrifice,
A moment paused to make a book of fate,
A history devoid of love and hate.

But more: All over oriental lands
From time to time great cities spread their walls,
Whose ruins slumber deep on fertile plain,
Where rivers flow in haste to join the main.
Their roster vast is book of final doom,
And every rolling hill is but a tomb.

In occidental lands, as ages came,
A thousand thousand villages were built,
To flourish under rule of chief and priest
And be o'erwhelmed by war of man and storm;
Their lengthened roll a scroll of many tongues,
Their history the tale of many tombs,
Their book of wars illumed by clubs and darts,
Their book of deeds illumed by shards of arts.

Song.

Centuries come and centuries go;
Solitude reigns where monarch was crowned,
Battlements crushed and minarets low,
The cities are strewn over desolate ground.

Gone are the years and gone are the folk;
Lost is the tale of opulent life;
Whelmed by the years or whelmed at a stroke,
The cities are gone with their turmoil and strife.

Capitol wrecked, metropolis crushed,
Palace in dust and temple in ash,
Tyrant in tomb and orator hushed,
The cities are gone in the centuries' crash.

THE TOMB BOOK.

The peaks and crags and minarets of mount,
With crimson coronets and golden glow,
Forever and forever doff their crowns
And hide their mourning heads in clouds of woe
As souls depart from life in vale below.

Through many centuries of rolling years
Mankind has marched, around this planet ball,
Adown the broad highway of teeming life
To death's grim portal, open wide to all,
Beyond whose gate there spreads a mystic pall.

And on they course in armies to the gate,
Their greeting e'er a song of joyous tone,
Their farewell e'er a requiem of grief;
From joy to grief the phalanx marches on,
Beyond the pale where multitudes have gone.

Still on they come, adown the sequent years,
With cheer and glee and loud exultant boast,
In tribes and nations pouring down the way,
Forever coming in a mighty host,
Departing ever to the mystic coast.

Beside the cradle way to coming life
Fair Joy forever stands with arms unfurled,
In camis white, resplendent as the day,
Her golden tresses by the breezes curled,
To greet arriving hosts to beauteous world.

Beside the postern way from life to death
Wan Grief forever leads the weeping band.

In trailing robes of sorrow's sable hue
For hosts departing to the unknown strand,
From region filled with light to shadow-land.

Wherever copse of blossom life is spread
Has rocked some cradle watched by mother's eye;
The soft south wind afanning baby cheek,
A low sweet song ahushing baby cry,
And fond caress asoothing baby sigh.

Wherever continents and islands rise
Above the restless wave of boundless main,
There every rood of land is ancient grave;
And round this portal all the weeping train,
With sobbing bosoms, chant the sad refrain.

The lullaby of Joy is never hushed,
The threnody of Grief is ever rife;
But canticle and ululation mix
In weird and dithyrambic hymn of strife
That echoes down the corridors of life.

Alas, pale Death has wandered round the world;
His footprints mark the universal earth;
His trails are meshed in every glade and wood,
And tombs on tombs are piled to dismal height,
And bones with bones in ossuary laid,
And skull by skull in circling ranks displayed.

In mounds were placed the dead of early man,
And multitudes of tumuli were built
In tropic forest, palm grove, cypress wold,
In fiord and glen and stony glacial plain,
And on the sand spit built by stormy main.

That peace might reign they stored beside their dead
The simple wealth acquired by skilless toil,
As garments, weapons, tool of handiwork,
And baskets, vases, ornaments, and toys,
And all the primal store of childish joys.

The customary deed became a rite,
Repeated o'er as sacred gift to love,
Until at last religion sealed it meet
As sacrifice to dear ancestral shade,
An offering to unseen spirit made.

Where flows the Tennessee from mountain founts
In sweeping curves to River Beautiful,
Among magnolia groves of attar rich
And tulip trees whose blossoms strew the ground,
There ancient clustered graves are stone-wrought cists
That hold the last remains of tribes unknown,
Above whose forms the mighty oaks have grown.

On River Green that flows from mountain tarn
To wed the River Grand, whose source is found
Where asters, gentians, and lilies grow,
Whose silent song is melody of light,
There cairns are built above the long-lost dead,
And every native swart who journeys by
Adds stone to stone in pious memory.

Beneath Andean peaks whose summits rise
Above the tide of wide Pacific sea
A sand dune stretches bleak to naked shore,
Where men are tombed in vestments wrought of wool,
The wondrous tapestries of Gobelin,
In weird necropolis of old Ancon,
The city eld by hosts of time o'erthrown.

Where turbid Tiber creeps o'er ancient plain,
Among the ruin vast of elder world,
Past tomb of emperor and tomb of slave,
The hosts of dead are stored in catacomb,
The gloomy subterranean hall of Rome.

Where Kedron's rills roll on, as Jordan rolls,
To fill the Dead Sea vased in Palestine,
Jerusalem the mighty stands to guard
The Sacred Sepulcher where Mary stood
And wept her Lord and Love and Life and Hope.
Anon the armies meet and warfare wage
To win Redeemer's tomb as battle gage.

In Afric highlands, where the mountains rise
To kiss the clouds and woo their welcome snows,
Great rivers flow with waters sweet and pure,
To join where lands are swept with wild simoons
And waves of Nile are stained with drifting dunes.

The Nile-fed desert homed an empire vast,
Once kinged by Pharaohs whom Moses knew,
Who ruled o'er hosts of slaves, the spoils of war.
These weary toilers, urged by tyrant lash,
Wrought mighty blocks from distant granite cliffs,
And built the pyramids as tombs for kings
Who sought through mummied death new life to gain
And wondrous immortality obtain.

Where mighty city stood in ancient time
A mausoleum housed a silent king,
Embalmed and wrapped in vestiges of waste.
Now titles proud and history are lost,
But refuse cerements have a story lore
More highly prized than scripture tomes of yore.

A melancholy book, this tome of tombs,
Whose leaves are scattered over all the earth.
No pinion plucked from wild bird's soaring wing,
And no papyrus from the reedy bank,
No pitchy ink, compound of gum and soot,
Were made to serve the author's unkenned task.
Ah, little dreamed he of the curious lore
He writ in silent sepulcher of yore.

The book of rocks and book of ruins sad
And book of tombs that house the many dead
Are triune tomes of archeology
That tell the tale of long-departed men,
The unremembered folk of years agone,
Whose bards had not the skill of pen and press
To tome their tales in book scriptorial;
But yet in amber deeds their lives were cast,
The prehistoric tribes and nations vast.

Song.

The wind drifts dust on ancient thorp,
And the waves spread their ooze over hamlet of lake;
The wild beast roams where pueblo stood,
And the storm sweeps the sand over cliff-dweller's wake.

The talus tombs the cavate lodge,
And the river engulfs the pantheon proud;
The desert creeps o'er ancient mart,
And the hurricane weaves for the city a shroud.

Volcano dooms Pompeii fair,
And the gates of old Babylon swing nevermore;
Palenque sleeps in tropic wold,
And the Andes are dirging Huanaco of yore.

J. W. POWELL.

CRITICISMS AND DISCUSSIONS.

THE MONISM OF "THE MONIST,"

COMPARED WITH PROFESSOR HAECKEL'S MONISM.

Professor Haeckel is a dear old friend of mine. Though my senior in years he has always been very cordial to me, nor has our friendship been marred in the least by my criticism of his conception of monism.. In fact it was quite impossible to make him reply to my strictures and I found out that it takes two to quarrel. He answered me in his letters and repeated it orally in conversation, "We mean the same," and I am only sorry that he cares so little for the differences to which I attach much importance.

Like Haeckel I accept the scientific world-conception which can only be monistic. I reject like him any kind of dualism, especially spiritism, viz., the belief in the existence of spirit in itself. At the same time I believe in evolution, not only the evolution of animals, but also of mankind, especially of human thought, of science, of religion and religious beliefs and institutions. Religious ideas are not mere fancies or inventions of a fraudulent priesthood; they originated with reference to the realities and the needs of life.

While my friend Haeckel would interpret the God-idea to mean matter and energy, as he said in a letter published in *The Open Court* for September 17, 1891,[1] I insist that the God-idea has always had in its historic development a moral significance. It always stood for justice, righteousness, truth, goodness, etc., and on the ground

[1] Compare also the following articles on Monism: "Professor Haeckel's Monism and the Ideas God and Immortality," *Open Court*, V, 2957-8. Cf. also the author's articles: "Professor Haeckel's Monism," *The Monist*, II, 598, in answer to Haeckel's "Our Monism," *The Monist*, II, 481; "Haeckel's Theses for a Monistic Alliance," *The Monist*, XVI, 120; "Monism, Dualism and Agnosticism," *Open Court*, I, 209; "The Religious Character of Monism," *Open Court*, II, 1381, in reply to "Christianity and Monism" by Dr. Gustav Carus, *Open Court*, II, 1379; "Professor Haeckel's Confession of Faith," *Open Court*, VII, 3528; and Mr. Edward C. Hegeler's article "What the Monistic Religion is to Me," *Open Court*, I, 725.

of this consideration I define God as "the authority of conduct." I claim that we can trace such authority of conduct in our experience and so I declare that it exists; it is a natural law; it is the same law according to which mankind develops higher and ever higher. There is punishment for wrong doing, there is a curse on sin, there is a blessing on righteousness; and the factors in objective reality which cause these results whatever they may be, have been personified and are called God. We can make no mistake in retaining this impressive name as one of the most important terms in our language.

The moral law is ultimately the same law as the totality of all the laws of nature; it is merely the application of the law of cause and effect to social conditions, and this God-conception may fairly well be characterized as nomotheism. God is the lawdom of the world, and by lawdom I understand what the Germans call *Gesetzmässigkeit.* Lawdom is the world's constitution as a law-ordained whole, consistent with itself in all details so as to appear as a system of uniformities. Thus the cosmic order makes the impression as if it were governed by an omniscient and omnipresent ruler, and the obvious efficiency of this intrinsic and immanent order has led to its personification as God. Atheism is wrong when denying with the name God this moral law of the world. Atheism is right only in so far as the constitution of the cosmos is not an individual being such as we poor mortals are, but theism is right when it insists on the objective significance of truth and of right and of all other ideals as a real factor in the formation of mankind. This is a God-conception which the atheist can not deny if he but believes in ideals, moral or scientific or artistic. It is the God-conception of science.

Nomotheism is neither the traditional theism nor is it pantheism, for the God of science is not identical with the All, nor is it a deification of nature. The God of science is neither matter and energy nor the totality of all existent things; it is the law that shapes them, the factor that governs their origin and growth, the eternal norm which determines the destiny of the world as a whole and also in its parts. It is the intrinsic consistency which exists in and by itself and would exist even if nature did not exist, and so it is in the literal sense of the word (though not in the traditional interpretation) supernatural.

It might be well to add that it would be wrong to call the God of science "impersonal" because God is the factor which creates personality, and so God is the condition of personality, and this higher and more scientific conception of God we prefer to call

"superpersonal." God is not less than a human person, he is more. He is the standard and supreme norm of personality.

In the opinion of spiritualists I am perhaps just as much a materialist as Professor Haeckel, but I insist on the paramount significance of what is called spirit, soul, mind, and of all the spiritual values of life. In fact there are no higher values than spiritual ones, and material goods possess value only so far as they are or can become serviceable for spiritual enhancement.

The soul originates in and through brain functions, but it is unsubstantial and non-energetic. The spiritual is constituted by the meaning of the several brain functions, by their significance, and above all by their purpose. Meaning is not made of matter nor does it consist of energy. Meaning is neither brain nor nervous function. It is a mere relation, and one might consider it as non-existent, in the sense that it is not a concrete thing. Meaning is the reference of one thing to another. Meaning originates when certain definite forms of feeling or sensations stand for certain definite realities. From these simple beginnings mind grows.

There is one point that must be emphasized: Form is more important than matter, and the relational of greater consequence than energy. Thus it comes to pass that the spiritual, this significance of brain functions, becomes hyperphysical. Though non-material and non-energetic, it is real, being an efficient factor in moulding things and guiding the affairs of life. Without this meaning of brain functions, without this purpose-pursuing quality of living beings, or as we commonly say, without the spiritual, without the presence of the soul, life would be a senseless jumble, and the world would be a mere chaotic display of physical forces. From this subtle quality of meaning alone rise all the wonders of human aspiration and moral endeavor, all values of life and also our religious and artistic ideals.

I cannot enter here into further details of how on the basis of this monistic conception many important problems find their proper solution. I will note only two: First, man is held responsible for his acts, and the thought of his responsibility enables him to criticize himself, to control and to judge of his several impulses, and to rise beyond his present condition by improving his character. This is practically the meaning of the belief in freedom of will.

Further, evolution means the continued life of former generations, which is an immortality in the race, and presupposes that all of man's most individual tendencies are preserved to serve as a basis for further progress. In the souls of the generations to come there

are many mansions for "those immortal dead who live again in minds made better by their presence" being "the choir invisible whose music is the gladness of the world."

Professor Haeckel thinks that there is a streak of dualism left in my conception of monism, but he is mistaken. He simply fails to understand my use of the words "God," "soul" and "immortality," while in my opinion he has not carried out his monistic principle into a full appreciation of the spiritual values of life. The origin and nature of the soul has to be explained without resorting to dualistic or vitalistic assumptions, and that is the work which I have done.[2] I recognize that the soul is not merely an accidental byplay of the functions of matter, and that in it the universe reveals itself in its full grandeur. Though the soul is not matter and not energy, it is the highest efflorescence of the development of natural forces. Professor Haeckel knows this all very well, but in his writings he shows himself so much the advocate of natural science *versus* superstition that he associates the words "God" and "soul" with a reactionary conception of religious dogmatism. Professor Haeckel ought to realize that a scientific conception of God and soul is possible, for he endorses fully Goethe's God-conception, and sees no dualism in it.

The truth is that there is not only matter and energy, but there are also the relational conditions; there is form, and form is more important than substance. Meaning originates from form, just as differently shaped letters represent the various sounds. There is a similarity or at least a correspondence between the things sensed and the several sensations, and their similarity makes the several sensations represent the several things sensed. Sensations are feelings that have acquired meaning, and from meaning rises the whole domain of spirit.

We must consider that Professor Haeckel is a naturalist, not a philosopher, and he has paid little attention to a consideration of religious questions. Nor is there any harm in this for we can not expect him to be at home everywhere. He was brought up in circles

[2] A condensed statement of my philosophy has appeared in English, German and French under the title *The Philosophy of Science* and an Italian version is in preparation. It explains in the short space of less than fifty pages the most important problems and treats among other topics the following subjects: The foundation of mathematics and logic, cause and reason, organized nature, subject and object, personality and self, the origin of consciousness, preservation of form in the flux of life, memory the soul-builder, truth the measure of man, pleasure and pain, free will, immortality, and the God of science.

of a very narrow-minded conception of an unprogressive protestantism and had much trouble to rid himself of the dualistic errors which placed him from the start in a wrong attitude towards religion. For a long time he was very patient with his antagonists, and it is quite excusable if here and there he goes a little too far. Have not his enemies gone too far in their attacks on him? They have painted him as black as a devil. I need not add that Haeckel's love of truth, his sincerity, his scientific honesty, and the kindliness of his character are genuinely religious.

As to the main point, however, concerning my differences with Professor Haeckel, I feel sure that he agrees with me better than with himself, and I hope he will pardon me for the statement.

EDITOR.

SCHOPENHAUER ON NEWTON AND HOOKE.

[In connecton with Mr. Philip E. B. Jourdain's article on "Robert Hooke as a Precursor of Newton," we venture to publish these extracts from Schopenhauer's writings to call attention to his position with regard to the priority of the discovery of the laws of gravitation between Newton and Hooke. Although some of the details may be inaccurate, Schopenhauer often hits the nail on the head. It cannot be denied that indirectly or directly, Hooke provided a great stimulus for Newton.—ED.]

In order to appreciate the great value of the gravitation theory which Newton perfected, to say the least, and placed on a positive foundation, we must recall the state of perplexity in which thinkers had been for millenniums with regard to the movements of the celestial bodies. Aristotle represented the universe as composed of transparent concentric spheres, the outermost of which contained the fixed stars, each of the succeeding ones a planet, and the last the moon; the nucleus of the machine was the earth. Now, what the power was that kept this system constantly in rotation was a question to which he had nothing to say except that there must be a *πρῶτον κινοῦν* somewhere—and this answer men have since been so kind as to interpret as theism, whereas he did not teach the existence of a creative God, certainly not that the universe is eternal, and barely a first motive energy in his cosmology. But even after Copernicus had replaced that fabulous construction of the world-machine by the correct one, and also after Kepler had discovered the laws of its motion, there still remained the old perplexity with regard to the motive force. Aristotle had assigned to the spheres

an equal number of gods for their direction. The scholastics transferred this direction to certain so-called "intelligences," which is simply a more pretentious name for the good angels each of which now drove its own planet. Free thinkers like Giordano Bruno and Vanini later knew no better than to make the planets themselves a sort of living divinities. They were followed by Descartes who always tried to account for everything in a mechanical way, but could conceive of no other motive energy than impact. Accordingly he assumed an invisible and intangible substance which surrounded the sun in layers and pushed the planets forward, the Cartesian vortex.

How childish and trivial all this is, and how much therefore we ought to value a theory of gravitation which has demonstrated incontestably the motive causes and the forces effective in them, and this so positively and accurately that even the slightest deviation and irregularity, acceleration and retardation, in the course of a planet or satellite can be perfectly explained and exactly computed from its nearest cause!

Hence the fundamental notion of making gravitation, which is known to us directly only as weight, the controlling force of the planetary system, is such a supremely significant one because of the important consequences following upon it that an inquiry with regard to its origin deserves not to be set aside as irrelevant; especially as we ought to strive to judge correctly at least as posterity, since we are so seldom able to do so as contemporaries.

It is well known that in 1686[1] when Newton published his *Principia* Robert Hooke raised a hue and cry about his priority in its main contention; and also that the bitter complaints of himself and others forced from Newton the promise to mention them in the first complete edition of the *Principia* (1687), which he did with the fewest possible words in a scholium to Book I, prop. 4, cor. 6, in the parenthesis, "*ut seorsum collegerunt etiam nostrates Wrennus, Hookius et Hallaeus.*"

[1] The *Principia* was not published until the next year and there seems to be no evidence that any one but Newton and Halley saw the proof sheets in 1686 although it is possible that Halley showed them to his acquaintances. In April 1686 Halley announced to the Royal Society that the *Principia* was almost ready for the press, and soon afterwards the manuscript of the *first Book* was presented to the Society. The book was licensed to be printed in July, 1686 (the "Imprimatur" was signed on July 5). Printing was begun just before this, and the first sheet in proof was sent to Newton on June 7, 1686. The second Book of the *Principia* was not sent up for printing until March, 1687, and the third shortly after this. The complete work was published in the midsummer of 1687.

That in the year 1666 Hooke had already propounded the essential part of the gravitation theory (though simply as an hypothesis) in a "Communication to the Royal Society" we can see from the main passage of this treatise which is reprinted in Hooke's own words in Dugald Stewart's *Philosophy of the Human Mind,* II, p. 434. In the *Quarterly Review* of August 1828 there is a good concise history of astronomy which treats Hooke's priority as an established fact.

In Michaud's *Biographie universelle,* comprising about one hundred volumes, the article "Newton" seems to be a translation from the *Biographia Britannica* to which it refers. It contains the representation of the universe according to the law of gravitation literally and *in extenso* according to Robert Hooke's *An Attempt to Prove the Motion of the Earth from Observations,* London, 1674, 4o. The article further states that the main point, namely that gravitation extends to all the celestial bodies, had already been expressed in Borelli's *Theoria motus planetarum e causis physicis deducta,* Florence, 1666. Finally it gives Newton's long reply to Hooke's above-mentioned claim to the priority of discovery.

On the other hand the apple story which has been repeated *ad nauseam* is without foundation. It is first mentioned as a well-known fact in Turnor's *History of Grantham,* p. 160. Pemberton, it is true, who knew Newton personally, although only after he had become old and infirm, relates in the preface to his *View of Newton's Philosophy,* that the thought first occurred to Newton in a garden, but says nothing about the apple; this was a later plausible addition. Voltaire claims to have heard it orally from Newton's niece, which is probably the origin of the story. See Voltaire, *Elémens de philosophie de Neuton,* II, chap. 3. A note to Byron's *Don Juan* (Canto X, stanza 1) says: "The celebrated apple-tree, the fall of one of the apples of which is said to have turned the attention of Newton to the subject of gravity, was destroyed by wind about four years ago. The anecdote of the falling apple is mentioned neither by Dr. Stukeley nor by Mr. Conduitt, so, as I have not been able to find any authority for it whatever, I did not feel myself at liberty to use it.—Brewster's *Life of Newton,* p. 344."

To all these authorities contradicting the assumption that the great conception of universal gravitation is a brother to the fundamentally false theory of homogeneous light, I have one more argument to add, which to be sure is only a psychological one, but will

have considerable weight for those who know human nature also from its intellectual side.

It is a well-known and undisputed fact that Newton at a very early period, it is said as early as 1666, either of his own accord or with outside aid, had conceived the theory of gravitation and sought to verify it by applying it to the orbit of the moon; that nevertheless, because the result did not exactly agree with the hypothesis, he finally let the latter drop and abandoned the subject for many years. Equally well known is the cause of the discrepancy which frightened him away. It arose simply from the fact that Newton took the distance of the moon from the earth as almost 1/7 too small, and this again because the distance can be first measured only in diameters of the earth; the diameter of the earth is computed from the length of the degrees of the circumference of the earth, and only these latter can be measured directly. Now Newton used the degree merely in its common geographical acceptation as containing 60 English miles in round numbers, whereas in fact it has 69½. The result was that the orbit of the moon did not agree with the hypothesis that gravitation is a force decreasing according to the square of the distance. Hence it was for this reason that Newton gave up the hypothesis and dismissed it. Not until about sixteen years later, that is, in 1682, did he learn of the measurement of degrees, completed by the Frenchman Picard some years previously, according to which the degree was almost 1/7 larger than he had formerly supposed it to be. Without considering this of much importance he made a note of it in the Royal Society where it was communicated to him from a letter, and then proceeded to listen attentively to the lecture without being at all disturbed by the fact. Not until afterwards did the old hypothesis occur to him. He again took up his calculations with regard to it and now found the state of things to correspond to it exactly, whereupon he fell into great ecstasies, as everybody knows.

Now I ask every one who is himself a father, who has himself begotten hypotheses, who has fed them and nursed them, does a man thus treat his own children? When everything does not go just right, does he at once thrust them out of the house without mercy, slam the door shut, and not ask a word about them for sixteen years? Would he not much more likely in a case like the present, before pronouncing such a bitter "There's nothing in it," suppose the mistake to be anywhere, even in the creation of the Heavenly Father himself if need be, sooner than in his own beloved child that he had

brought into life and carefully cherished?—and especially in just that point where suspicion might so easily have found its rightful place, namely in the only empirical datum (besides the one angle) upon which the calculation was based, and whose uncertainty was so well known that the French had been carrying on their degree measurements since 1669, in spite of which uncertainty Newton nevertheless had made his assumption according to the popular acceptation in English miles. And a man could be so misled with a true and elucidating cosmic hypothesis? Never, *if it were his own*! On the other hand, I can tell you likewise what children are treated in this way: foundlings who are taken reluctantly into the home, at whom (on the arm of his own barren wife) the man looks askance with envious eyes and puts to a test only from a sense of duty, hoping they will not stand the test, and as soon as this is confirmed throws them out of the house with jeers of ridicule.

This argument is of such great importance, at least to me, that I recognize in it a complete corroboration of the evidence which ascribes the fundamental conception of gravitation to Hooke and leaves to Newton only its verification by calculations. According to this view Hooke has fared as badly as Columbus: the continent is called "America," and gravitation is called "Newton's theory."—*Parerga und Paralipomena,* II, Section 86.

* * *

No science imposes upon the multitude so much as astronomy. Accordingly the astronomers who for the most part are ready reckoners of very ordinary capacity, put on great airs with their "most exalted science" and similar expressions. Even Plato joked about these claims and called to mind that what is exalted is not necessarily that which happens to be above us (Rep. L. VII).

The almost idolatrous veneration which Newton enjoys, especially in England, exceeds all belief. Just recently he was called in the *Times* "the greatest of human beings," and in another article in the same journal an attempt is made to console us with the information that we may feel assured that he nevertheless was only a man! In the year 1815 (according to the report of the weekly *Examiner,* printed in *Galignani,* Jan. 11, 1853) one of Newton's teeth was sold for 730 pounds sterling to a lord who had it set in a ring, which tale reminds us of the sacred tooth of Buddha. Now this ridiculous adoration of the great master of calculation rests on the fact that people take as the measure of his merits the size of

the masses whose movements he has reduced to their laws and these to the force of nature therein operative (which latter, moreover, was not his discovery but Robert Hooke's which he merely confirmed by calculation). Otherwise we cannot see why more honor is due him than to any other who has reduced given effects to the expression of a definite force of nature, and why, for instance, Lavoisier should not be valued as highly.—*Parerga und Paralipomena,* II, Section 80.

* * *

Hooke's discovery of the law of gravitation, and the reference of so many important phenomena to this one law, was the work of immediate apprehension by the understanding; and such also was the proof of Newton's calculations, and Lavoisier's discovery of acids and their important function in nature, and also Goethe's discovery of the origin of physical colors.—*World as Will and Idea* (ed. Haldane and Kemp), I, 26.

* * *

It cannot but disturb us very much if we find minds of the first order under suspicion of dishonesty, which would be a scandal to those of the lowest order. For we feel that theft is even more inexcusable in a rich man than in a poor one. We dare not, however, be silent; for here we are posterity, and must be just, as we hope that posterity will be some day to us. Therefore, as a third example,[2] I will add to these cases, that the fundamental thoughts of the "Metamorphosis of Plants" by Goethe, were already expressed by Kaspar Wolff in 1764 in his *Theory of Generation,* pp. 148, 229, 243, etc. Indeed, is it otherwise with the system of gravitation? The discovery of this is always ascribed to Newton on the continent of Europe, while in England the learned at least know very well that it belongs to Robert Hooke, who in the year 1666, in a communication to the Royal Society expounds it quite distinctly, although only as a hypothesis and without proof. The principal passage of this communication is quoted in Dugald Stewart's *Philosophy of the Human Mind,* and is probably taken from Robert Hooke's *Posthumous Works.*[3] The history of the matter, and how Newton got into difficulty by it, is also to be found in the *Biographie universelle,* article "Newton." Hooke's priority is treated as an established fact in a short history of astronomy in the *Quarterly*

[2] The first was Kant's dynamics previously expounded by Priestley; the second was Laplace preceded by Kant.—Ed.

[3] See Mr. Jourdain's article on another page.

Review, August, 1828. Further details on this subject are to be found in my *Parerga,* Vol. II, Section 86 (second edition, Section 88). The story of the fall of an apple is a fable as groundless as it is popular, and is quite without authority."—*World as Will and Idea* (ed. Haldane and Kemp), II, 225-226.

EARLIER THEORIES OF GRAVITY.

It is universally conceded that gravitation is the most incomprehensible of all forces. Gravitation is supposed to be included in the law of conservation of energy, and from one point of view there is doubtless evidence to show this. When a body is poised upon the edge of a table, let us say, it possesses a certain amount of potential energy. When that body falls to the ground, its potential is converted into actual or kinetic energy. The energy is therefore released from the body which now possesses none. The energy it once possessed has been expended and converted into the work of the world, or its energy has been radiated uselessly into space; and thus we see how gravitation, the attraction of the earth for all material bodies, can be made to enter into the circle of generally recognized forces and included in the law of conservation. It might be questioned whether potential energy *is* energy in the strictest sense of the term, but I shall let that pass for the moment and assume that these facts prove what they are said to prove.

Gravitation is certainly the most mysterious of all known forces, and even yet nothing definite can be said as to its *modus operandi.* In the case of all other forces known to us it is possible to shut off their influence, to find some body which is opaque to their power. Take, for instance, light and electricity. Roughly speaking, glass permits the passage through it of light rays but prevents the passage of electric rays. Steel on the contrary, being a good conductor, permits the passage through it of the electric current but is impervious to light. The same is true of all other forces with the single exception of gravitation. No body has been found opaque to gravitation. It seems to exert its influence above, below, and equally upon all sides of any object. The introduction of a solid sheet of metal, of glass, or of any substance whatever, seems to have no appreciable effect. The body beneath which it is introduced seems to be attracted to the earth by gravitation just as strongly as it was before the introduction of such a sheet. And yet, from all that we know of force and energy, such should not be the case! We are

confronted by an insoluble mystery. What is the nature of this force? How can it be conceived to act? What speculations have been advanced by men in the past to account for this mysterious phenomenon which has so puzzled the world since Newton's first famous experiments?

It is interesting to note that Newton himself speculated on this subject, and some years before arriving at his great generalization he threw out a suggestion as to the cause of terrestrial gravity in a letter to Boyle. In view of the recent experiments performed by the Cambridge school in England, by Dr. Gustav Le Bon and others in France, and by various other scientists—demonstrating apparently, that matter is resolvable into ether, or a mode of energy within the ether—the following extract from his letter shows remarkable foresight upon his part and deserves preservation. Writing in January 1678, Newton thus unfolded his hypothesis:

"First, it is to be supposed that there is an etherial medium, much of the same constitution as air, but far rarer, subtler, and more strongly elastic, but it is not to be supposed that this medium is of one uniform matter, but composed partly of the main phlegmatic body of the ether, partly of other various etherial spirits, much after the manner that air is compounded of the phlegmatic body of air, intermixed with various vapors and exhalations; for the electric and magnetic effluvia, and the gravitating principle seem to argue such variety. Perhaps the whole frame of nature may be nothing but various contextures of some certain etherial spirits or vapors, condensed as it were by precipitation, much after the manner that vapors are condensed into water.... *Thus, perhaps, may all things be originated from ether.*"

Newton's own theory of gravitation he formulated thus:

"I will suppose ether to consist of parts differing from one another in subtlety of indefinite degrees, in such a manner that from the top of the air to the surface of the earth, and again from the surface of the earth to the center thereof, the ether is insensibly finer and finer. Imagine now any body suspended in the air, or lying on the earth, and the ether, being by the hypothesis grosser in the pores which are in the upper parts of the body than in those which are in the lower parts, and that grosser ether being less apt to be lodged in those pores than the finer ether below, it will endeavor to get out, and give way to the finer ether below, which cannot be, without the bodies descending to make room above for it to go into.... From this supposed gradual subtlety of the parts of the

ether, some things above might be further illustrated and made more intelligible."

It is well to bear in mind that every hypothesis which attempts to explain gravity is required *in limine* to give a satisfactory account of the following six characteristics of this mysterious influence:

1. Its direction is radical toward the acting mass, or rectilinear —indefinitely. This rectilinear traction is incapable of deflection by any intermediate force. It suffers neither disturbance nor interference from any multiplication of similar lines of action, and admits neither of reflection, refraction, nor of composition.

2. Its quantity is exactly proportional to the acting mass—indefinitely.

Corollary: Hence its integrity of action is complete with every accumulation of additional demand—indefinitely; this is to say, no multiplication of duty in the slightest degree impairs its previous tensions.

3. Its intensity is diminished by recession, in proportion to the square of the distance through which it acts—indefinitely; in a manner somewhat analogous to—but (as modified by the second condition) radically different from—the action of light.

4. Its time of action is instantaneous throughout all ascertained distances, and therefore, presumably,—indefinitely.

Corollary: Hence its rate of action, (if the expression may be tolerated) is precisely the same on bodies at all velocities—indefinitely. It no more lags on a comet approaching the sun at the speed of two hundred miles or more per second than on a body at the lowest rate of motion, or than on the same comet receding from the sun at the same velocity.

5. Its quality is invariable under all circumstances—indefinitely. It is entirely unaffected by the interposition of any material screen, whatever its character or extent; or, in other words, it can neither be checked by an insulator nor retarded by any obstruction.

6. Its energy is unchangeable in time, certainly for the past two thousand years; presumably—indefinitely.

Corollary: Hence, its activity is incessant and inexhaustible—indefinitely; the ceaseless fall of planets from their tangential impulses involving no dynamic expenditure in the sun or in other known matter.

Let us now give a rapid summary of the theories that have been advanced from time to time to explain this mysterious force. Arago, in his *Popular Astronomy*, attempted to show that gravitation trav-

eled with fifty million times the velocity of light, and that the time required to reach us from the nearest star would be about two seconds. Philippe Villemot, a French doctor of theology and a distinguished mathematician, advanced a theory in 1707 that gravitation is occasioned by a difference of pressure on the outer and inner faces of the fluid constituting the solar vortex, owing to an increase of its density outward from the sun. The general conception is obviously somewhat similar to Newton's speculation hazarded in 1678. The next attempt at a solution was offered by Bernoulli, of Switzerland, who attempted to show that gravitation of the planets toward the center of the sun, and the weight of bodies towards the center of the earth, were caused by the immediate impulsion of a substance which he termed "the central torrent." This was continually thrown from the whole circumference of the vortex to its center, and consequently impressions on all bodies encountered by it in its path imparted to them the same tendency towards the center of the vortex.

Lesage, in 1750, was the next philosopher to advance a definite theory of gravitation. To quote Arago's exposition of the theory, it was as follows:

"A single body placed in the midst of such an ocean of moving corpuscles would remain at rest, since it would be equally impelled in every direction. On the other hand, two bodies ought to advance towards each other since they would form a mutual screen, as their opposed surfaces would no longer be hit by the ultra-mundane corpuscles in the direction of the line joining them, and there would then exist currents whose effect would no longer be neutralized by opposite currents. Moreover, it will readily be seen that two bodies plunged into such a "gravitation fluid" would tend to approach each other with a force varying inversely as the square of the distance."

While this theory finds some support from facts known to science, and has even been called "the only plausible answer to this great problem which has yet been propounded," yet the theory utterly fails to acount for many of the known facts, and seems to be in contradiction to others. All that can be said for it is that, unlike most other theories of gravitation, it is at least conceivable and has some faint beginnings of scientific precision.

Leonard Euler, a Swiss mathematician and philosopher, published in 1760 a treatise in which he commented on the action of gravitation as follows:

"Supposing a hole made in the earth through its center; it is

clear that a body at the very center must entirely lose its gravity, as it could no longer move in any direction whatever, all gravity tending continually toward the center of the earth. Since then a body has no longer gravity at the center of the earth, it will follow that in descending to this center its gravity would have gradually diminished; and we accordingly conclude that a body, penetrating into the bowels of the earth, loses its gravity in proportion as it approaches the center. It is evident, then, that neither the intensity nor the direction of gravity is a consequence from the nature of any body, as not only its intensity is variable but likewise its direction, which on passing to the antipodes becomes quite contrary."

Herapath next, in 1816, published an essay "On the Physical Properties of Gases." He attempted to show that there was "one cause for heat, light, gravitation, electricity, cohesion, aërial repulsion, etc., from which all these flow, and are deducible; and their effects may be computed by mathematical induction [deduction?]. It shows us that gravitation, cohesion, and affinity are but the same thing under different modifications; that the differences of the two latter arise from a difference in the figures and sizes only of the particles; that attraction and repulsion are not properties of matter."

Herapath contended that, by noting the continued and mutual condition of particles of gases in the containing vessels, and by extending the principle to the planets, which he supposed to be all of the same density as the earth, he attempted to show that it was possible to calculate the amount of gravity of varied bodies, one toward another. There were of course several fundamental defects in his theory, so obvious that they need hardly be mentioned. The known dissimilarity of the composition of stellar bodies, and the fallacy that any pressure-differences would result from temperature-differences, naturally vitiated his whole argument.

The next ingenious attack upon the problem was made by Guyot in 1861 in an essay entitled "A Sympathetic Glance at the Form and Forces of Matter." Still maintaining that all the properties of bodies are derivatives of their vibratory movements, and that the equilibrium and the phenomena of the world exist only under the condition of constant pressure of the ether upon coercible matter and the reaction of the latter upon the former, he argues that "if it be shown that the vibration of the atoms of bodies may and actually does cause the rarefaction in the sphere of activity of each of the atoms," this constitutes a proof that "the approximation of the atoms of bodies of ponderable matter is due to the rarefaction

of the imponderable fluid, and consequently to the diminution of its pressure in the space between the atoms of the same body"; and hence that "we are compelled to admit that attraction is a mechanical force, consisting first of the rarefaction of the ether between molecules, masses, or the heavenly bodies, resulting from the ceaseless vibration of the atoms of ponderable matter; and secondly of the reaction from the exterior pressure of the ether upon the same, resulting from the general pressure of the imponderable universal medium which constitutes the *mother-liquor* of the world."

In 1844 Faraday issued a speculation on the nature of matter in which his first unformed views were stated. This was followed in 1850 by a memoir on the possible relation of gravity to electricity, in which he stated his belief that there was such a definite connection, though he could give no proof of it. Several years later in a memoir on "The Conservation of Force" he gave the results of his further meditations on "the attractive theme of gravitation." They were these:

"It is a simple attractive force, exerted between any two or all the particles or masses of matter at every sensible distance, but with a strength bearing inversely as the square of the distance.... For my own part, many considerations urge my mind toward the idea of a cause of gravity which is not resident in the particles of matter, merely, but constantly in them and all space. I would much rather incline to believe that bodies affecting each other by gravitation act by lines of force of definite amount or by an ether pervading all parts of space, than admit that the conservation of force could be dispensed with."

On no subject, perhaps, have the distinguished author's ideas been more vague and intangible than on this.

The next speculations of note are those by Seguin, submitted to the French Academy of Sciences in 1848 and 1858. In his earlier writings he held to a crude kinetic theory, founded upon the laws of cohesion, repulsion, attraction, etc. In 1858, however, Seguin published in the *Cosmos* a somewhat elaborate essay on the origin and propagation of force, in which he seems to have abandoned the kinetic theory of gravitation. It is true that he there holds that "matter is inert; that is to say it does not harbor in itself the power to put itself into movement, and still less, *a fortiori*, to communicate it, since a thing to be transmitted must first exist." And it is also true that he repeatedly speaks of "the great principle of infinite conservation of motion" as being the foundation of all mechan-

ics, and regards the possibility of destruction of motion as equivalent to annihilation of force.

Notwithstanding all this, he says in regard to the uniform tendency of a material system towards its center of gravity:

"We are thus led to consider attraction as a first cause, emanating directly from the Divine Will in the creation of matter. Doubtless, it is not impossible that it may hereafter be discovered that attraction in its turn is only a consequence of a more general law, comprehending in itself more implicitly the means of explaining the effects attributed to attraction.... But as these considerations are purely metaphysical since observation cannot reach beyond the established fact that two confronting bodies gravitate toward each other by virtue of a force to which is given the name of 'attraction,' it appears to me wiser not to advance further to penetrate a mystery which nothing within our knowledge as yet appears able to explain. Let us then consider matter as existing from the beginning, uniformly in space, and attraction as an essential property with which it is endowed, by virtue of which the different parts or molecules composing it possess in themselves the power of mutual attraction."

M. de Boucheporn read a memoir to the French Academy of Sciences, July 30, 1849, in which he attempted to explain the general laws of gravitation. It was based on the idea that the movements of the heavenly bodies might be explained by an external impulsion, or by the action of a universal fluid. He pointed out first, that the intensity of the impulse propagated in the etherial medium follows the law of the inverse square of the distance from the center of disturbance; second, that the resistance of the ether does not sensibly effect the velocity of a body when this is sufficiently less than that of the theory of propagation; third, that taking the density of the fluid as unity, the quantity of motion impressed by a body on the ether is equal to its volume multiplied by the square of its velocity; fourth, that the pressure would produce the effect that all layers of equal thickness would include the same quantity of matter if propagated to the interior of the heavenly bodies, and that the mean density is three times that of the surface; "fifth, as to attraction, the displacement of the ether by the movement of a body, A, will produce in all parts of the fluid a sort of aspiration toward the point being left by its center; and any body, B, receiving these aspiring waves on its nearer hemisphere, will have lost all or a part of its own pressure, and the half pressure (volume multiplied by the square velocity) which acts on the opposite hemisphere, no

longer being counterbalanced, will give an impulse to the body B, in the direction of A. Such would be the principle of attraction."

In a learned work on elasticity, Gabriel Lamé, in 1852, next attacked the problem of gravitation. He insisted on the necessity for admitting an all-pervading ether. Having theoretically proved its existence, he contends that it is scarcely to be doubted that in the intervention of the ether is to be found the secret or true cause of the effects which are attributed to heat, to electricity, to magnetism, to universal attraction, to cohesion, to chemical affinities. For all these mysterious and incomprehensible agencies are at bottom but coordinating hypotheses.

In 1858 J. J. Waterston, of Edinburg, published an essay entitled "On the Integral of Gravitation, and its Consequence with Reference to the Measure and Transfer or Communication of Force." He contended that "a force-generating faculty exists in space and is directed centripetally. The mutual gravitation of two bodies," he said, "develops mechanical force in each of them, inversely proportioned to its mass." The theory is really very indefinite throughout, since he appears to make gravitation a function of space, being the content of space, or the dynamic medium supposed to occupy it. It may be said that his speculations have failed to find corroboration.

Prof. James Challis, in 1859, published a series of communications beginning with his mathematical theory of attractive forces, and following it through in other papers on "Force," and "Gravitation." He found the theories of elasticity, cohesion, attraction and repulsion in matter insufficient to account for the facts, and was forced back upon the ether. "Yet," he says, rightly enough, "as it is contrary to principle to ascribe elasticity to atomic matter, the question might arise, why is it more proper to ascribe this occult property to the ether?" Concluding that we cannot, he stated his conviction that "we must conceive *another form of ether,* having the same relation to the first as that has to air." In 1876 this author returned to a discussion of the problem. In dealing with the residual effect of vibration, which, he said, "is the attraction of gravity," he says:

"This result expresses the force of gravity as due to the attractive action of a molecule of a higher order as to magnitude than the molecule of molecular attraction. For distinction, a molecule of this superior order might be called a gravity-molecule. Its magnitude may still be considered to be so small that in comparison with

the magnitudes of terrestrial and cosmical masses, it may be treated as an infinitesimal quantity....Lastly, it is to be noted that on account of the large value of λ for gravity-waves they do not suffer sensible retardation or refraction in passing through gross bodies. I have on several previous occasions treated of the problem of gravitating force theoretically, and by slow steps have approximated to its solution; but before the present attempt I had not succeeded in exhibiting satisfactorily the *rationale* of this kind of attraction by vibrations."

In 1861, Mr. J. S. Glennie published in *The Philosophical Magazine* several papers on the subject of gravitation. Summarizing his own views in later articles, Mr. Glennie thus recapitulates and states the substance of his theory:

"Matter is conceived to be made up, not of an elastic ether and inelastic atoms, but of elastic molecules of different orders as to size and density. If a rough physical conception of these molecules be required, they may be conceived as etherial nuclei, the ether of the nuclei of a lower, being made up of nuclei of a higher, order, and so on *ad infinitum.*"

Mr. Glennie postulated a universal repulsion, varying through various intensities, instead of universal attraction; but, could it be discussed in detail, it must be said that his theory completely fails to be convincing.

Keller in 1863, Tait in 1864, and Saigey in 1866, all offered speculations upon this subject, based more or less on their theory of force. Saigey went so far as to say that bodies do not owe their gravity to an intrinsic force, but to the pressure of the medium in which they are immersed. Why this pressure should vary at various points in the universe is not stated.

In a communication to *The Philosophical Magazine* in 1867, Mr. James Croll revived the difficulties that had been stated by Faraday and attempted to solve them. He was first of all led to the conclusion that there must be, in order to account for the facts, a destruction of force in one place and a creation of force in another. Finding, however, that this ran counter to the law of conservation of energy, he gave up that attempt and attacked the problem in a different direction. Discussing it from the point of view of the law of conservation of energy, he pointed out that if gravity be correlated to other forms of energy, it must be included in the law of conservation. But here he was met with difficulties. Admitting that gravity can perform mechanical work, and mechanical work can

be converted into other forms of energy, he yet pointed out that it is generally denied that there is a decrease or loss of gravity resulting from such transformations, that is, the body did work without losing any of its force of gravity. It would therefore appear to be outside the law of conservation. After much theoretical discussion, Mr. Croll arrived at the following conclusion: That gravity is in all probability of the nature of an impact or pressure. Finding he could not account for it either on the theory that it resulted from the impact of corpuscles or from the difference in pressure of a substance filling space, he was forced to the conclusion that it was some kind of "pure force."

In 1869, P. Leray published an essay entitled "A New Theory of Gravitation." In this he postulated first, the existence of an ether; second, that at every point there exist equal currents crossing each other in all directions; third, that in passing through bodies the currents of the ether are retarded proportionately to the thickness traversed and to the mean density of the path. In the same year Boisbaudran published a short paper entitled "A Note on the Theory of Weight." His conclusion was: "It is to the longitudinal vibrations of the ether that I attribute the cause of weight." Guthrie in 1870 published an account of some experiments entitled, "On Approach Caused by Vibration." His hypothesis practically made gravitation a function of temperature, which was of course, contrary to all observation.

Sir William Crookes in 1873 offered some speculations in which he pointed out the possible influence of the energy of light-waves as effecting the results, but his statements at that time were little more than restatements of the difficulties, and he had no positive theory of his own to offer.

Lord Kelvin, in his essay "On Ether and Gravitational Matter Through Infinite Space," in 1901 said: "The potential energy of gravitation may be in reality the ultimate created antecedent of all the motion, heat, and light at present in the universe." It will be observed that his definition is really vague and does not attempt to tell us what the *kinetic* energy of gravitation may be. Speculations have also been advanced on this subject by the Cambridge school, by Sir Oliver Lodge, Dr. Gustav Le Bon, and others. It is hardly necessary to say, however, that their articles have consisted almost entirely of accounts of the difficulties to be faced by any theory advanced, and but little has been offered by way of positive theory.

It may be said that the newer discoveries in physics have had

a double bearing upon this problem. The experiments carried on of late years may, perhaps, have furnished us with the first outlines of a possible reconstruction; a comprehension of the facts. On the other hand, they have made the phenomena more mysterious than ever! Gravity has no appreciable action on electricity, while it is the sole reason of the laws governing the flow of liquids. Nevertheless, it more nearly resembles electricity than any force we know. As Dr. Le Bon said in his *Evolution of Forces*: "One gets clearer and clearer glimpses that weight is due to the relations between the ether and matter, connected, doubtless, by lines of force; but this is only a more or less vague hint, which still escapes the teachings of experiment. It is possible that the gyratory movement of the atoms are communicated to the ether and through it to the different material bodies, thereby establishing an attraction between them. The reciprocal attraction of vortices has, at the present day, been demonstrated by many experiments.... Gravitation displays the incomprehensible characteristic, which no other manifestation of energy possesses, of not being arrested by any obstacle. The most delicate researches have shown that no body exists which is opaque to gravitation. Gravitation is a very small force if we consider only the action of the masses we have at our disposal, but it is a force extremely great for considerable masses. This power is apparent to us every day in the phenomenon of the tides. Under the influence of the combined motion of the sun and moon, the seas are raised to an average height of one meter, which represents a weight of one thousand kilogrammes per surface-meter.

"Physicists have been able to say nothing more on gravitation than what is said above. In an important memoir of which I reproduce a few passages, Prof. Vernon Boys has shown perfectly how inexplicable it remains. 'It seems to defy,' he says, 'all our attempts to abandon the inconceivable idea of action at a distance; for even when we might conceive another mode of action it is entirely incomprehensible that gravitation should act at a distance without regard to the existence or nature of bodies in its path, and, as it appears, instantaneously.... The speed of the propagation of gravitation was estimated by Laplace as being immensely higher than that of light. Henri Poincaré considered it as propagated with a velocity of the order of that of light vibration. We do not know how gravitation is propagated, but it seems to me that the law of the inverse square of the distance allows us to imagine gravitic waves having a form analogous to that of the waves of light, electric

waves, etc.....When a force decreases with the distance in accordance with this law, it is legitimate enough to imagine that it is propagated by spherical waves. This should be the case with gravitation."

So long ago as 1876, Mr. William B. Taylor, in his valuable essay on gravitation, pointed out the difficulties in the various theories that had been advanced by way of explanation. The corpuscular theory, even in his time, he regarded as finally and conclusively disproved. The hypothesis of undulations he regarded as equally impossible. He pointed out that such undulations as had thus far been established were quite incapable of inducing anything in the slightest degree analogous to gravitation, and that the new species of undulation necessary for the theory have never been proved. Great as is the credit due to Professor Challis, for instance, for his laborious efforts to develop this theory by the stern logic of mathematics, the whole demonstration is vitiated by the unwarranted preliminary assumption of qualities and modes of action in the ether analogous to those of gases; but experiment has failed to demonstrate any such similarity. Even if the undulation postulated were proved it would be entirely inadequate to account for the facts. The experiments of Guyot and Guthrie quite conclusively show that neither in the law of quantity nor in the law of intensity can gaseous vibrations represent even approximately the ascertained facts of gravitation embodied in the general propositions. The difficulties presented by inertia, elasticity, etc., have likewise never been overcome.

Failing thus at every point, the hypothesis leaves still more inscrutable the *origin* of the undulation. The center of disturbance is supposed to be the vibrating material element; but the *cause* of the vibration is never stated. If "innate tendency" be the answer, never surely was a more mysterious "occult quality" attributed to matter in the history of physics. Force cannot originate without an originator. The new discoveries in physics have thrown an entirely different light over this problem, causing us to reconstruct our views as to the nature of matter and energy, and their interrelation. Matter, in fact, has been resolved into energy and springs from it. We have the universe traced back to a homogeneous primal ether in rest. Once this ether receives an initial impulse, then all the rest would follow—etherial vibrations, electric atoms, material atoms, worlds, the universe! And into ether all shall return! What caused that prime initial impulse? That we cannot say. Science says that "forces unknown to us" caused it to emerge. It is possible to con-

ceive that this first grand impulse was none other than some human or divine Will.

Nevertheless, granting a prime mover—the immediate operation of a demi-urgus, if necessary—the difficulty would still remain: How is the initial impulse converted into vibration? What is the resisting power deflecting the element in motion from that rectilinear direction which is the first law of action? Upon that subject there is a very remarkable reticence. Is the universe a perpetual motion machine?

There is no reason whatever to believe that the ether is a *source* of energy. We have no experience of any undulations originating in its broad expanse. It is never self-luminous; and even in the case of electricity there is always required the disturbance of a material element. Nor it there any ascertained fact to warrant the supposition that the ether is a *reservoir* of force, in any other sense than that, without the possession of intrinsic tension, it would be incapable of transmitting energy (I am using the terms "matter" and "force" here as they are commonly understood). There is a great deal of loose speculation current regarding the nature of this supposed ether. Dr. A. Rabagliati, in his introduction to my *Vitality, Fasting and Nutrition,* called attention to this, and said: "But what is this ether? M. Le Bon tells us, or at least suggests to us, that it is a solid without density or weight. Some scientists indeed suggest to us that the ether has density and no weight, while others say that it has weight and no density! These are the men, be it observed, who speak somewhat disparagingly of 'purely metaphysical considerations.' They deduce their conclusions from 'experiments.' But are not the definitions purely metaphysical? And are they any less so because deduced from experiments? It is a highly interesting state of mind which uses metaphysical expressions, and justifies them because they are alleged to have been come to by 'experiments' and not from philosophical considerations. A solid without density or weight! What is such a body? Is it nothing? I suggest that it is—nothing. But according to the thesis, it is the origin, and it is again the grave of the atom. The atom then came from—nothing, and it goes back to—nothing. But is not this the very proposition which, when it has been stated by philosophic or religious men, has been sneered at by the scientists? It is the very proposition! But then it was made for metaphysical speculation, and now that it has been stated from physical speculation (is that it?) or from experimentists, it is allowable! Nay we must yield

our consent to it. All I can say is, that never have I been asked to believe anything more transcending reason by any philosopher. The scientific men and the physicists and the experimentalists seem, certainly, to have got themselves into a quagmire regarding this solid without density or weight, and I wish them well out of it."

Thus the nature of ether cannot be said to be much more clearly defined than that of gravitation. Both remain unsolved mysteries, closely related to one another, and present many similar difficulties. Perhaps some "metaphysical Newton" will one day solve the problem!

HEREWARD CARRINGTON.

NEW YORK.

THE FRENCH NEWTON.

She was, in fact, a woman of genius.
Ernest Renan.

In the early days of our civilization, men, being finer, more intelligent, more keen-eyed and more joyful than to-day, became universally impassioned for Truth and Justice, those two lovely sisters upon whom we modern civilized people, herded into loathsome cities and indulging too often in tiresome, stupid toils, seem to look now with indifference and contempt. True sons of nature, amidst which they lived peacefully, they knew not yet of equatorials and telescopes, of experimental retorts, tubes and flakes, of balloons for experimenting in the upper regions of the air and drags and nets for researches into the lower regions of the sea, of registering thermometers and barometric charts, of scientific cinematographs and wireless Marconi. Indeed their five senses were so acute, so subtle that they almost amounted to a sixth one. Lovers of life and beauty with which their poetical souls were ceaselessly enraptured, and too respectful of natural life to irrationally imprison it in barbarous fashions, they enjoyed themselves in constantly developing their marvelous gifts, either in long journeys through mountains and valleys, forests and pastures, jungles and deserts, or in adventurous travels upon the liquid plains, or also during long pauses for rest on the verdant, fragrant islands, or by the well-sheltered shores of Hellas and its Asiatic colonies!

In such a splendidly luminous era—far too short, alas!—which rejuvenated humanity from the extreme east of Asia to the western

extremity of the Mediterranean world, about seven hundred years before the advent of Jesus, these giants of human thought sprang up. This wonderful constellation of geniuses whose thought, too deep and too synthetic for the narrow minds of the academies, remained misunderstood and practically unknown to the Athenians, who were then comparable in ignorance, frivolity and disregard of truth and justice to our "civilized people" of the present day! Later, Greece and its direct heirs, Rome and medieval Europe, paid indeed a costly price for this incomprehensive attitude of their fathers towards those who brought in themselves the salvation of the ancient world! Unable to oppose the smallest barrier to the invasion of the Oriental gods, antiquity in its last days became the prey for Paul's monotheism, that intolerant, dreadful curse which for nearly two thousand years usurped and retained the place in public opinion which should have been occupied by the luminous and valuable doctrines of the Ionian and Abderite philosophers!

Buried so many centuries under a colossal heap of falsehood and crime, the Ionian philosophy, like the phoenix, was suddenly restored to life on the banks of Lake Geneva, about half a century ago! Hesitating at first and doubtful of itself, it soon recovered its senses and rapidly assumed the full consciousness of its strength and value. Then appeared from time to time, in many periodicals of both continents, masterful studies on much discussed subjects. About twenty years after this miraculous resurrection, the grand, sublime natural philosophy, already reconstructed in all its parts, reappeared as suddenly as Minerva from the brain of Zeus, condensed and concluded beforehand in a small code of the Logos in which the logical law governing the whole of life was formulated once for all.[1] Finally, in the year 1900, a Parisian publisher edited the Bible of synthetic science, a wonderful, unique philosophical work, opening unlimited perspectives to all minds that long to penetrate the riddles of the cosmos!

Perhaps at this point I shall somewhat astonish my readers when I say that the philosophical brain that undertook and brought to an end such a titanic work was a feminine one! Yes, the "French Newton," the immortal writer of "The Constitution of the Cosmos" and of "The History of the Heavens" was one of those creatures condemned by the Catholic church as utterly vicious, malignant, haunted by devils, one of these creatures whom current ethics proclaimed irretrievably stupid! This really extraordinary woman,

[1] *Le bien et la loi morale.*

this vast genius whose bold, though generally just, inferences revolutionized science was Clémence Royer, the translator and intelligent critic of Darwin's *Origin of Species* who upset the old erroneous principles of theoretical science, declaring they had hitherto shown only the reverse of realities, and who, while playing with steel balls, discovered the molecular constitution of water in its three states and consequently the approximate constitution of the greatest number of chemical bodies.

But this is only one among the many inspirations of the great forgotten woman philosopher, inspirations which have thrown such dazzling light into dark branches of knowledge. The overturning of the hypothesis of attraction is another one and not the least important in its consequences. Adopting the beautiful conception of Demokritos who had guessed that the cosmos is filled entirely with elastic fluid units, Clémence Royer, with a remarkable power of induction, showed that all phenomena in nature are explainable and explainable only through this process of perpetual repulsion between the atoms. In fact, such a system is far in advance of the Bergsonian concept of a "dynamical continuity." Here in Clémence Royer's theory we have at last an integral definitive philosophy of nature, whereas the Bergsonian thought is only a very misty, esoteric, superficial one, only a very timid insight of a logical truth already duly discovered!

Other very remarkable inductions of the "French Newton" have been corrective of and complementary to the Darwinian theory. Let us only quote here the two principal ones. One is the hypothesis of the plurality of organic sources rediscovered recently by the Mary Brothers and called by them *polyphyletism*. The other is the theory of long polar rotations whose admission now explains most of the enigmas of geology and paleontology. We may say here that the history of the earth from such a standpoint is an extremely interesting science, much more beautiful, much more pleasant than Jules Verne's and H. G. Wells's novels. To-day we can clearly realize how the ancestor of man, naked and without natural weapons, forever left his oceanic abode in the same period as all the ancestors of reptiles, birds and mammals; how he fought for the conquest and exclusive possession of the land against the other living species; how finally he took their place and destroyed them without restraint and discrimination; how in our own days, upon this planet conquered by him, he goes on to seek for his rule and law which he will not find until he has attained a thorough insight of his environ-

ment, of his true nature, of his true situation in the cosmos, until he will have realized how to harmonize his own life with the life of the cosmos!

Such, in a few words, is the original conception of the cosmic substance rediscovered, reconstructed in all its parts and considerably extended by the cyclopedic brain of a woman. Such is the immense, the grand synthetic philosophy, both cosmic and human, far the finest, the most complete, the most exact of all, in fact the only one which is exact, the only one which supports discussion, the only one worthy to be studied and nevertheless the most unjustly misunderstood, the most blindly criticized, the most stubbornly and systematically boycotted by all sects, whatever they may be! At the very moment when I am writing these lines, eleven years have elapsed since the death of the "French Newton," and with the exception of a few cuttings reprinted here and there by sympathizers, not a single one of her immortal works has been reprinted yet, not a single one of her unpublished manuscripts has been published by the committee she entrusted with the duty of seeing to their publication. It is true that this committee is yet unaware of its own existence, as I ascertained by a recent letter from one of its members. At the present day, atomistic dynamism is not taught in a single school in Paris! No French scientific group, except one composed of two dozens of adherents, takes any interest in the diffusion of the rational doctrine! Yet, two years ago at the Stanislas College in Paris, under the direction of Jesuits, M. Saulze made a most stupid criticism of the theory of "Mademoiselle Royer." More than that, in October, 1912, six hundred copies of my little book, *L'atome fluide,* suddenly disappeared from their place of storage, stolen or perhaps destroyed by a hand supposed unseen! It is clear that a new cosmic theory which hunts Jehovah out of the universe prevents its supporters from enjoying peaceful sleep!

But truth is an invincible force! Having awakened from her long lethargy, she has resumed her course at last, and if her first steps were rather clumsy and uncertain, she is now treading an onward path and nothing can stop her advance throughout the world. Without being a prophet, I can foretell that my booklet, of which but a few hundred copies have been bought, will be translated tomorrow into many languages, that by the mere force of truth it will indeed become a great success, and that each copy of it which has been stolen will bring me at least a thousand readers! In

UMI

September, 1912, a few weeks before this imbecile deed was committed, the International Freethought inaugurated a memorial inscription at the farm of Praz-Perey on the banks of Lake Geneva, at the house in which Clémence Royer's thought freed itself from darkness and prejudices and opened to the light of scientific truth. The ceremony at Praz-Perey was exceedingly simple, indeed such as Clémence Royer herself would have wished it. Unfortunately, when I read the speeches delivered on that day, I had the impression that the speakers did not exactly realize the true extent, value and import of the work that the immortal woman leaves behind her. As to ourselves, having spent six whole years in diffusing and completing the doctrine, we can advance it as the remedy which our humanity is waiting and hoping for in order to be cured once for all of the religious mania and of that discomforting skepticism which results from the loss of one's dearest creeds and beliefs!

ARISTIDES PRATELLE.

PARIS, FRANCE.

DR. EDMUND MONTGOMERY: AN AFTERMATH.

The late philosopher Dr. Edmund Montgomery, who died on April 17, 1911, an obituary sketch appearing in *The Open Court* for July, 1911, left as the crystallization of his intellectual life two important volumes: *Philosophical Problems in the Light of Vital Organization* and *The Revelation of Present Experience*. The former received extended notice in *The Monist*, Vol. XIX, No. 4. The latter was reviewed editorially in the issue of July 1911. In comment on our review of this book Charles Alva Lane writes to *The Monist* expressing disagreement with the reviewer's assertion that Dr. Montgomery "bases his monism upon a mental substance as ultimate reality," and Mr. Lane's strictures are similarly urged by William M. Salter.

Mr. Lane expresses his criticism in a letter as follows:

"It seems incredible that you would charge Montgomery with theistic tendencies, even though he 'favors a teleological interpretation of nature'—the Charybdis into which he runs in his efforts to escape the Scylla of the mechanistic creeds.

"In his attempts to define the ultimate reality Montgomery has, indeed, been compelled to bring to bear all his lingual dexterity, for it requires pretty deft juggling of thought to avoid identifying

the *substance* of his 'matrix' with the 'soul-stuff' of the theosophists or the 'spiritual body' of St. Paul.

"So far as I can remember, Montgomery's closest approach to a definition of that which he characterizes as veritable and only substance is as follows: 'This steadfast producing matrix cannot possibly be of the same nature as the changeful, evanescent phenomena that transiently arise in the conscious content.' Later he writes: 'These hypothetical existents, inert matter and moving motion, cannot rationally be conceived as endowed with memory.' Thus his 'substance' is, apparently, of neither mental nor physical consistency. He classifies it as 'extra-mental' though he adds this may seem paradoxical. It is a specific element of existence brought into kinetic conditions through vital organization only. Its 'steadfastness' has probably a physical basis, and its synthetizing power amid the elements of the conscious content is analogous to the crystallizing properties of the chemical compounds. That affinities respond in the thought-world is really less marvelous than the operations of mere chemical affinity. The real marvel lay in the fact of the interaction of these disparate sets of affinities. Since organic structure results solely from vital functioning, the material of structure must be, in some wise, affinitively related to the specific energies of vitality; and mental states, whether causative of functioning or mere concomitant epiphenomena, must, in turn, reach over in some manner and get into rapport with the somatic basis of structure.

"Montgomery's 'matrix' seems to be a sort of central work-shop of all these multipotent activities. But is it, after all, of mental consistency, even though its products be mainly mental?

"To Montgomery there is, above all things, an extraconscious entity that must be reckoned with, and the character of which, save in inadequate simulacra and representative symbols, is incommensurably beyond the powers of our ken. In the human body its most marvelous development has been attained. Organic life chemically originated from it, drawing with it the potencies involved in the elaboration of sentiency, consciousness and the activities of mentality.

"Nowhere, so far as I can recall, does Montgomery use the expression 'mental substance.' Always his 'substance' is a substrate of the fleeting pageantry of mental states. It is that 'extra-conscious matrix which latently preserves past experiences,' and without which 'no conscious content whatever will arise into awareness.' This has

its seat somewhere in the recesses of the perceptible body, and by dint of its regenerative qualities 'maintains its identity and efficiency unimpaired, while producing or emitting a sustained manifestation of natural phenomena, being in fact the proximate source of this becoming of conscious appearances.' Mentality, then, is a most specific outcome of a process which is basically chemic, and liberated, Montgomery might say, from the essential potencies of the substratum of life—that extra-conscious world which keeps in most permanent and intimate rapport with life through that steadfast condition of the ectodermic structures which yields the sense of identity amid change.

"The 'creative trend' of organic substances, and indeed of all nature as manifested in the evolutionary processes, is a feature of existence which Montgomery distinctly ascribes to intrinsic efficiencies, no supernatural mental substance, or *ab extra* teleological impulse being concerned in the process."

So far Mr. Lane.

In the light of Mr. Lane's objections, we have reconsidered our description of Dr. Montgomery's monism as being based upon a "mental substance" and will say that all depends on the meaning we, and in this case also Dr. Montgomery, may attribute to the term "mental substance." In personal conversation, if we remember rightly, Dr. Montgomery did ascribe a nondescript mentality (not a fully developed mind with brain action and discursive thought but the cause of it) to the substance of his matrix; we will not however insist that he used the term "mental." Certainly he would not have identified (to use Dr. Lane's words) "the substance of his matrix with the 'soul stuff' of the theosophists or the 'spiritual body' of St. Paul." Nor did we ever understand Dr. Montgomery's philosophy in that light. However, similar terms have been used by other authorities, as for instance Clifford whose conception of "mind-stuff" is well known. We do not believe that Dr. Montgomery would have objected to a comparison of his own with Clifford's view. Dr. Montgomery's notion of substance which he called "extra-mental," was certainly not purely material, and it was to him the source of all mentality.

We have good reasons to assume that Mr. Lane is thoroughly familiar with the latest works of his friend, and so we will grant that therein the term "mental substance" is not used, but we shall see later on that Dr. Montgomery did use it in former writings

of his, although he uses it in a somewhat different sense. We do not insist on the term, but we believe that Montgomery's conception of a matrix implied the idea of a substratum which might be characterized as mental substance, for he ascribed to it the potency of mind. Our interest in Dr. Montgomery has been more of a personal nature and we feel that the public will be interested in becoming better acquainted with his character and the closing events of his life.

The problem of philosophy uppermost in Dr. Montgomery's mind was the nature and origin of the individual, a problem of which we have offered our own solution in a little book entitled *Personality*. Dr. Montgomery's solution was different. He saw the shortcomings of Virchow's cell theory and claimed that an aggregate of many cells would remain so many cell-consciousnesses but can not constitute a human personality. The cells know nothing of us and we know nothing of the cells—ergo there must be a central monad. Here Dr. Montgomery's views remind us of Goethe's soul monad which the great German poet assumes to constitute man's entelechy.[1]

We will let Dr. Montgomery explain himself in extracts which we quote from his essays published in the prime of his life. He says:[2]

"To us it matters really not one jot whether our nerve-cells, if such we have, do possess inward experience, or not. Our consciousness is clearly not their consciousness. Our *I* cannot be possibly composed of any *we* of theirs. In irrelational solitude, each of them has to enjoy for ever its inner life utterly incommunicable, utterly exclusive. There can be, as we have plainly seen, no vital synthesis of their sundry intrinsic activities. No vital cell-medium is at all conceivable, in which their respective inward experiences could be combined as joint-effect. Their individual functional commotions, if at all accompanied by feeling, have to ring out separately without power of ever sensorially or inwardly influencing each other's lives in the least degree. The billions of cells of which the organic being, as a 'cell-aggregate,' is thought to be composed, are just so many elementary organisms, with just so many elementary functions, with just so many elementary unrelated sensorial experiences, if at all endowed with feeling.

"Our inner life, on the contrary, consists of a unitary synthesis of most complex and diverse relations to other beings. It can therefore have nothing whatever to do with the many and primitive lives

[1] See the editorial article on "Goethe's Soul Conception" in *The Open Court*, XXI, p. 745.

[2] Quoted from an essay published in 1880 under the title "Are we Cell-Aggregates?"

of nerve-cells. If, as we are all positively convinced, the nervous system is nevertheless subservient to our sensorial and other mental experience, it certainly cannot be so by dint of the inner lives or sensorial experiences of its 'cells.' The only conclusion to which the cell-theory here necessarily leads is, that the specific vital commotion of nerve-cells must be construed as stimulating a unitary, hypervital substance to those activities which we call our mental life. Indeed there have to be hypostatized in vacancy the virtues of exactly such a substance, as I, in my counter-theory, have conceived the nervous system itself actually to be. The initial points of sensorial stimulation, instead of being situated at the sensory inlets, would have to be shifted to where the central 'cells' have to impart their sundry specific commotions as stimuli to a mental substance.[3] Under this arrangement nerves would be 'field-telegraphs' indeed, but the 'headquarters' and the central telegraph operators would be found nowhere within the confines of this world.

"It is only want of insight that has hitherto prevented spiritualistic reasoners from utilizing, as a solid basis of operation, these inevitable conclusions of our present biological science. I would earnestly recommend to them the serious study of biology. The science that has of late so discomposed the even tenor of their thought, is now once more at their mercy. It is open to the humiliating taunt that, setting out with the avowed aim to explain life physically and chemically, it breaks down before ever reaching physics and chemistry. With the full mystery of vitality still on its hands within its units, the 'cells,' it fails even then to put complex life together out of the vital material it assumes. It is in the power of those who believe in a hypervital substance of mind, to force upon biologists the consciousness of their shortcomings.....

"If cell-theorists persist in flattering themselves with the adequacy of their doctrine, still continuing to ignore its flagrant inconsistencies and shortcomings, even after they have been again clearly pointed out to them, it cannot alter the fact, that they are lagging far behind in their understanding of life. Perhaps, however, they may think it now worth their while to attend to the difficulties here exposed. If so, I may entertain some hope, that they will come to learn from nature the lessons forced upon me by an unprejudiced yielding to her teachings. Then we shall be delivered from the ludicrous position of having, *secundum artem,* to consider ourselves a congregation of ever so many primitive lives, and shall feel scien-

[3] Here Dr. Montgomery uses the term "mental substance."

tifically restored to the full dignity of indivisible, autonomous personalities."

Mr. C. A. Lane writes to the editor concerning the use of the term "mental substance" in this passage, as follows:

"Montgomery is here demonstrating the inadequacies of the cellular hypothesis, contending that to logically complete the chain of phenomena which forms the biological problem, there must be 'hypostatized in vacancy' a mental substance 'to be found nowhere within the confines of this world,' but ready-made and supernaturally equipped with endowments for receiving and transmuting into mental forms the sundry specific commotions initiated by sensorial stimulation.

"To Montgomery there was no such mental substance existing in vacancy, for he distinctly asserts "the virtues of exactly such a substance" abide in the functions of the nervous system of the indiscerptible unitary being,—a system phyletically developed by a specific chemical process most intimately interrelated with the influences of the environment. The inscrutable chemical activities and concomitant mental manifestations of this sensori-motor nerve-system are perpetuated by reason of a self-reintegrating attribute which maintains, through mnemonic properties, the sense of identity amid change, so constituting a veritable substance. But mentality is only one of its manifestations, albeit the most remarkable."

In another article entitled "The Unity of the Organic Individual," Dr. Montgomery offers his solution of the problem of the soul which in his opinion the cell theory fails to give, and we quote from it the most important argument as follows:

"It is only fair to confess that chemical activity, with its definite selective preferences and its constructive origination of specific properties, is an ubiquitous energy at present completely beyond the reach of our scientific comprehension. Neither physical nor psychical interpretations have hitherto availed to throw any light on its mysterious nature. The various attempts at a mechanical explanation, i. e., at a reduction of chemical laws to the simple laws of mass-motion, have not even succeeded in offering a plausible suggestion as a hypothetical basis to start from. And with regard to our modern hylozoism, inspired by Schopenhauer and becoming prevalent even among the scientific celebrities of our time, it can only be said that it plainly proves that we have once more exhausted the combinations all round. We are growing conscious that our earnest and most determined efforts to make motion produce sensation and

volition have proved a failure, and now we want to rest a little in the opposite, much less laborious conjecture, and allow any kind of motion to start into existence, or at least to receive its specific direction from psychical resources; sensation and volition being for the purpose quietly insinuated into the constitution of the ultimate moving particles. If, however, evolution is to be our scientific creed, we can expect the great and good things only after strength has been gradually gathered through endless toil.

"Chemical elaboration then discloses itself as the secret activity of which the vital energies are concomitant manifestations. Of whatever ultimate incident chemical composition may be the perceptible symbol, to us it is the embodiment of a synthesis accompanied by the appearance of new properties, scientifically incalculable and unaccountable.

"The properties of the molecule of water are even less intelligible to us than the properties of the living molecule. Of the former we possess only a mediate knowledge; of the latter, also some little immediate knowledge.

"From point to point we are formulating the great truth that the centralized animal organism represents only one single monadic molecule."

* * *

For several years Dr. Montgomery had led an isolated life. His own cheery words will give some idea of his outlook on life after his last fatal stroke of paralysis. On June 18, 1908, he wrote to a friend as follows:

"I am now a prisoner for good, without hope of ever becoming able to leave my home again. I am, however, quite reconciled to my fate. My general health is good, my spirits never dejected. I live alone in the large colonial house, attended only by our faithful housekeeper, now 74 years old, who has been with us more than 40 years. She is getting very feeble, but insists upon letting no one wait upon me but herself. So to save her as much work as possible, I have reduced my wants to a minimum, and live in almost complete solitude, quite satisfied, for I am inured to solitude, and time never seems too long for me.....

"I never feel the want of any mere social entertainment, but there is no higher enjoyment for me than the exchange of thoughts with congenial companions. And one's inspiring ideas being understood and appreciated as they are by your poetic penetration, is rarest benison.....

"Personally I am indifferent to success, though I have never doubted the final outcome. The biological discoveries and the recognition of their significance have for years kept me in a glorious state of exultation that needed no outside fuel to keep it aglow. I find it quite natural, remembering how theological opinions of the crudest type are relinquished with the greatest difficulty, that it should fare in a similar manner with scientific and philosophical views. The facts of nature are perennial, but their interpretation changes with the nature of the interpreter and the state of knowledge attained."

Dr. Montgomery's acquaintanceship embraced a wide range of the world's most noted men during the past three-quarters of a century. His friends will be sorry to learn that the eve of his life was obscured by utter loneliness, making his demise almost tragic. The most intimate American friends of Dr. Montgomery were Judge Reese, of Austin, Texas; Rev. William M. Salter, of Cambridge, Massachusetts; Charles Alva Lane, of Alliance, Ohio, and finally the new owners of Liendo Plantation, Mr. and Mrs. Harris who, luckily for the lonely patient, were kindly disposed to him and very sympathetic. Judge Lipscomb, of the Warren County Court of Texas, writes as follows:

"It is a pity that a man like him should have spent his last days among strangers not bound to him by any ties. Otherwise it was very fortunate that he fell into the hands of such worthy people who did everything they could to make him comfortable and contented. Dr. Montgomery was one of the most polished and lovable characters that ever lived in this part of our state, and his memory will long be revered by those who knew him."

Concerning his last days we will quote a personal letter from Mrs. Harris, whose kindly services were tendered the lonely philosopher during his latter days, and who was present at his death.

"Liendo Plantation, Hempstead, Texas.
"September, 20, 1911.

"Mr. C. A. Lane,
"Dear Sir:

"Your letter to Mr. L. N. Montgomery has come to hand. In the absence of all the Montgomerys I am to open the mail.

"Let me first introduce myself. I am the wife of the new owner of the old Plantation and was with Dr. Montgomery in the big house many days before his death, the 17th of April last. We all loved

him. He had been very much alone since he was stricken with the paralysis which shortened his life, having with him only the faithful old housekeeper, Cenai, who came with them from Germany nearly fifty years ago.

"In looking over his correspondence I see many letters from you to the Doctor. After receiving such great honors in his youth and middle age, for such a brilliant intellect to be drifted out almost alone was a tragedy.

"I think you were in close enough touch with him to have learned much of his home affairs. I came to him a stranger, but he seemed to like and trust me from the first. His wife not taking his name made it very unpleasant in many ways. Miss Ney, you know, was a great sculptress and, with the eccentricities of an artist, entertained many queer notions. She would be simply 'Miss Ney,' never permitting herself to be called Mrs. Montgomery after the conventional manner.

"We came from the North and fell in love with the place, so bought it at once. He had sold it to a party three years before but retained a life lease on the home. This he gladly signed over to us. He still had his one thousand dollars a year from the estate of his father who was Lord Chief Advocate of Scotland. Through meddling outsiders Dr. Montgomery's one son had for some time been estranged from the father, but after Miss Ney's death a will was made by the Doctor leaving all to his son.

"Had he been near any of you, his closer friends, he would have been better off. There was no one here for whom he cared deeply, or who could sympathetically enter into his troubles. Being an outsider, I could readily see what havoc had been wrought upon his sensitive nature and brilliant mind. The son came and looked over the papers and letters. He knows nothing at all of his relatives. For twenty years he has been a sort of Ishmael in his parental home, though no blame, I think, need attach to either the Doctor or the son for these conditions. I will send your letter to the son. He will be more than glad to get any information you can give him. All the printed matter is here. The plates from which were printed *Philosophical Problems* remain the property of Dr. Montgomery by contract. Can you not secure and preserve these? The son will do anything you wish about them.

"All told, the Doctor left about $4000.00 in cash, but no property, and $3000.00 of this is in trust for the old housekeeper. At her death the fund goes to the son. The books were left to Judge

Reese. He took some and left the rest to the son. Some of Miss Ney's marbles should bring something, but now some one comes in with a Bill of Sale and claims them. But the Doctor never signed it. He told me so before his last fatal spell, and he was incapable of telling an untruth.

"The son has several children. He is of generous nature, quick-tempered, but unusually bright. German, French, Spanish, and Italian are as easy to him as the mother tongue.

"The Doctor desired no formalities at his funeral. He wanted but a few to attend, and he was buried in the yard at Liendo. At his request I placed the ashes of his first-born—a boy who died at the age of eighteen months—in the coffin with him.

"My heart ached to see him so alone. I filled his coffin with honeysuckles and the wild flowers he loved best. He looked like a piece of marble in his coffin. His grave and that of his wife are both in view from my window as I write, and often I carry flowers to strew upon the sacred spot. You see he had never told us to whom we should write, or I surely would have sent you word a month before his death. But if you had seen him you would have been only grieved, for he could not speak, and in his eyes there was such pitiful desire for utterance.

"He had not written much since his last book was issued. One day he said to me 'How we wear out our bodies and ruin our brains with all this foolishness! And now,' he said, 'I am done, virtually dead, and I have accomplished nothing to help the world or myself.' I think he referred to his scientific work which had not wholly satisfied him. 'Centuries hence,' he continued, 'men will, like myself, struggle with the same problems, never coming nearer to a solution.' Don't you think a vein of this sort runs through his last book? I have marked many passages which I think refer more to every-day life than any that are to be found in his former writings.

"I hope the son will find some of the manuscripts you would like. In the meanwhile you can write me if any copies of the Doctor's magazine articles would be of benefit to you. In a short time I will send you a photograph of him. I told the son to have some taken, as several European friends of the Doctor had asked for copies.

"Hoping to hear from you again, I am

"Very respectfully yours,

L. B. Harris."

A portrait of Dr. Montgomery reproduced from a photograph was published in *The Open Court* of March, 1912. The same number contains pictures also of his wife Elisabet Ney, her studio and some of her sculpture. P. C.

CURRENT PERIODICALS

The number of *Mind* for January, 1913, contains an article on "Rationalism and Empiricism" by George Trumbull Ladd. There is probably, he says, no other subject of controversy about which, and no other word under the cover of which, there has been more deplorable confusion and consequent inner bitterness and outward contempt than the subjects covered by the word "rationalism." "Strictly speaking, the words rationalism and rationalistic are properly used in philosophical terminology only as applicable to a certain *method* of exploring and ascertaining truth. Whenever they are used as applicable to the *content* of truth supposed to be thus ascertained, they are either misused or should be understood with caution. In violation of this caution, for example, pragmatism borrows the words, with all the opprobrium attaching to them in certain quarters, from the theological controversies of one and two generations ago, and in the name of empiricism holds up to ridicule and scorn many of the tenets of philosophy which were thought to be established on an empirical basis against the reigning dogmatism of that distant time. But rationalism is no more antithetic to empiricism than it is to idealism, or to realism, or to supernaturalism, or even to pragmatism. One might seem more justified in opposing it to scepticism; although it has almost invariably been identified with the most dangerous forms of scepticism when it has attempted to apply its method in a too unrestricted way to the problems of morals and religion. But on the one hand, one can neither theologize nor philosophize without some scepticism; and on the other hand, too much scepticism undermines all the authority and destroys all the work of reason, whether it be within the field of philosophy or theology, or even of the positive sciences."

S. Alexander, in a paper on "Collective Willing and Truth," continues the working out of a scheme of his for expounding psychological processes which depends on the principle that on the different levels of experience, perception, imagination, memory, and so on, there corresponds to each form of conation a certain form of non-mental object, or *cognitum*. The paper is to be continued,

and there are here published nine sections, which are concerned with experience of other minds, truth and intersubjective intercourse, goodness and truth, collective and individual believing, the science of truth, and mental propositions and their truth.

M. M. Pattison Muir deals with "Alchemy and the Absolute." "The Alchemists," he says, "were the most patient and thoroughgoing pursuers of absolute truth who have appeared among those who profess themselves scientific investigators. It cannot but be interesting to compare the aim, the method, and the phraseology of the alchemists, with the aim, the method, and certain technical expressions of the absolutist philosophers."

George H. Langley considers, in a paper on "The Metaphysical Method of Herbart," the method put forward by Herbart as the instrument by which inference can be made from the common concepts of experience to such knowledge of reality as shall render a rational explanation of experience possible. Herbart's philosophy is founded on Kant, as is Hegel's, though Herbart and Hegel are almost wholly opposed to one another. Hegel is the better known, for Herbart's attempt at continuation has been much ignored, and there is no English work on the subject; yet it is of interest as leading to a consistent pluralism.

In the "Discussions," there are three articles: one by B. Russell on some criticisms of G. Dawes Hicks on his views on sense-data in his *Problems of Philosophy*—this article contains a welcome and much more precise statement of his views—; H. P. Cooke has some remarks on his reviewer in "Ethics and the New Intuitionists"; and F. C. S. Schiller has a note on "Mysticism *v.* Intellectualism." Among the "Critical Notices," a notice by C. D. Broad of Meinong's book *Ueber Annahmen* is particularly to be noticed.

* * *

The number of the *Revue de Métaphysique et de Morale* for January, 1913, begins with an article by A. Meillet on the method of comparative grammar, where he describes the principle of the process of reasoning of the cultivators of comparative grammar and examines the demonstrative value of this reasoning. L. Weber, in an article on the rhythm of progress and the law of the two states, continues the working out of his hypothesis that intellectual progress, instead of obeying Comte's law of the three states, shows the kind of binary rhythm consisting in the alternation of preponderating influence of technical activity and speculative activity. Charles Dunan continues his study on the nature of space; the present article

is devoted to the nativistic conception of space. S. Ginzberg has a note on the equivocal meaning of particular propositions. "The quantification of the predicate, which is necessary when judgments are to be translated into equations, is quite useless for any one who only aspires to a satisfactory precision of the particular judgment. Thus I will accept as an interpretation of this judgment: 'Some and nothing but some S's are P's,' without asking whether S is subordinated to P or merely *crosses* with it. To express itself the particular judgment may say $v\mathrm{S} = v\mathrm{P}$ and $v\mathrm{S} = \mathrm{P}$, but not $z\mathrm{S} = v\mathrm{P}$. Thus, what I have done is the quantification of the subject." P. Boutroux has a critical study on L. Brunschvicg's *Les étapes de la philosophie mathématique*; and finally T. Ruyssen has a discussion on the practical question of temperance.

* * *

"Scientia" (*Rivista di Scienza*) begins its thirteenth volume with the number for January, 1913. It is described as an "International Review of Scientific Synthesis"; appears every two months; and contains French translations of the Italian, German, and English articles, as well as the originals. E Walter Maunder has an article on sun-spots, giving astronomical details on the cycles of sun-spot activity.

Marcel Brillouin has an interesting article on the principle of relativity. This theory has been described in *Scientia* in enthusiastic articles by Castelnuovo and Langevin; but the present article is by a sceptical physicist and sounds a critical note. The new theory ignores the ether, and we cannot do this because electro-magnetic disturbances, unlike gravitation, require a finite time of propagation: "The existence of the ether is as certain for us as that of the air could have been before the invention of the pneumatic machine and compression-pumps." It is refreshing to read that "everybody agrees" about the relative motion of two material systems. Here the question is about the relative motion of a material system and the ether, and it must be remembered that the velocities which we can produce artificially on systems of some size are very small as compared with that of light. The work on whether there is a relative motion of material systems and the ether or not, of Stokes, Lorentz, Michelson, Fitzgerald, and others is referred to. The association of rigidity with perfect permeability to the motions of matter was an enigma—no greater nor less than the permeability of an immovable ether to electrons in the theory of Lorentz. To avoid this, the relativists propose to adopt for the electro-magnetic field the abstract

and purely algebraic point of view which we adopt, in default of better, in gravitation, where we cannot find any velocity of propagation; then, having taken away every material support for radiant energy, they have been led to attribute to this energy the two principal characteristics of materiality, inertia and weight. To put at the beginning of the theory the new principle of relativity which is based on a few electro-optical observations, and to extend it to the whole domain of natural science, is not physical but metaphysical.

M. Smoluchowski has an interesting article on the number and sizes of molecules and atoms. He protests against the tracing of a scientific atomic theory to Leucippus, Democritus, and Lucretius. Modern physics is an exact science, and atomism as an exact physical and chemical theory does not go back beyond Daniel Bernoulli (1738). The work of Dalton (1808), Hauy (1784), Bravais (1849), Clausius, and Maxwell; investigations on the size of atoms as due to Loschmidt (1865), Lord Kelvin, Dorn, Exner, Van der Waals, O. E. Meyer; and then very modern researches are referred to. Hardly has physics attained the solution of a fundamental problem of atomism when a number of other riddles arise. It is well that this should be so: if not, physics were a dead science.

E. Rignano studies the psychological nature of reasoning. In his previous articles in *Scientia* on attention etc., he traced the phenomena from their manifestations in the case of the lower animals, but in this article he follows a different method and only analyzes certain of the simplest and commonest forms of reasoning with human beings; in a second article the evolution of reasoning will be considered, and in a third article a study of its higher forms will be made.

F. Kühnert has an article on ideographic writing with the Chinese, which is of the greatest possible interest in connection with the analogy that Chinese offers with the symbolic logic of modern times. The formation of the Chinese characters, in its four stages, is described, and a wish is expressed that, when European civilization spreads to China, the language and the writing will remain intact.

R. Dussaud writes on the part played by the Phenicians and the Mediterranean Sea in primitive times. This part was a great one both from the points of view of politics, commerce, and general culture. The present article does not trace the various stages of it so much as show the method by which its history must be made precise. It is very curious, in fact, that Phenician history has been

attempted to be founded by means different from those used in Greek and Roman history.

Finally, G. Marchesini criticizes Lemaître and maintains the modernity of the educational views expressed by Rousseau in his *Emile*.

* * *

The number for March contains a critical discussion by M. P. Rudski on the various methods for determining the age of the earth. These methods are: (1) that which depends on the theory of geological denudation and accumulation of deposits (Geikie); (2) that which depends on the theory of the secular cooling of the earth (Lord Kelvin and others); (3) that which depends on the salinity of the sea (the idea was due to Halley and the method has been developed in modern times by Joly and von Romer); (4) that which depends on the theory of the disintegration of radioactive matter (Strutt, Holmes, and Boltwood); (5) that due to G. H. Darwin in his researches on the evolution of the moon. The author concludes that, from whatever side we attack the problem we always arrive at the conclusion that the earth has a history dating back hundreds of millions of years.

E. Pringsheim contributes a somewhat technical article on radiation of heat and luminescence, which deals with the conditions under which Kirchhoff's law of radiation holds.

G. Henslow writes on ecology considered as bearing upon the evolution of plants. The word "ecology" was invented by Haeckel and means the study of plants and animals "at home." It is no longer enough for botanists merely to collect plants and examine the structure of their flowers and so on, solely with the view of their classification, as was formerly done; and it is ecology which everywhere reveals the origin of species by direct or self-adaptation to new conditions of life. This conclusion derived from the study of plant life is equally true for the whole of the animal kingdom.

F. Oppenheimer has a long article on value and excess value. The first part of this contribution to political economy is on the "monopoly" theory of excess value.

E. Naville writes on the scholastic method in the science of language. The word "scholastic" is not used in a depreciatory sense; it is defined as a method of argument founded on reasoning and not on facts of observation. In modern times people have begun to study living and spoken languages which are rapidly becoming obsolete; and the author believes that this science of linguis-

UMI

tics, which takes care not to construct, by the help of pure reasoning, theories which are logically very sound but are only artificial creations, is in the right direction.

R. Pettazzoni deals with the science of religions and its method. In the usual division of the study of the history of religions, non-civilized peoples are put on the same plane as civilized peoples of antiquity and of modern times; neither the historical method (a study in time) nor the comparative method (a study in space) ought to be exclusively used. There is, says the author, one thing which is certain. It is that we have not here to deal with two methods which we have to make to walk side by side, but with a unitary conception which is founded on the nature of the object—the religious fact which is one and definite in its essence—which is proper to it.

A critical note by A. Levi deals with the problem of morals as exposed in a book by Limentani. There are two general reviews; one by F. Botazzi on some fundamental concepts of the chemistry of colloids; and the other is by A. Van Gennep on the Iliad as an economical poem, with reference to Walter Leaf's *Troy, a Study in Homeric Geography* (London, 1912).

* * *

The first number of *Isis,* an international quarterly journal devoted to the history of science, appeared in March. The aim of this journal is to study the genesis and development of scientific theories, taking account of all the changes of ideas and influences that the progress of civilization constantly brings into play; and to unite all the materials necessary for this study and perfect its method and working-instruments. The ideal program of the journal is admirably sketched by the editor, Dr. George Sarton, in the first article of the number. After insisting on the necessity of closer relations between science and philosophy, he deals with the special subject of the journal: the history of science. The history of science as a whole, and thus as distinguished from the history of the sciences, was founded by Comte and continued, almost alone, by Paul Tannery. The definition of the history of science is that given above, and the author proceeds to examine, from the point of view of the interest they possess for this study: (1) the history of civilization; (2) the history of technology; (3) the history of religions; (4) the history of the fine arts; (5) archeological, anthropological, and ethnological researches. From the scientific point of view history has a great *heuristic* value, as has been emphasized, perhaps in rather

an exaggerated way, by Wilhelm Ostwald. The original work of the old masters of science is still full of treasures; and we must remember that not only is history important because there is often a recurrence of ideas in science—for example, some modern cosmogonies have forsaken Newton for Descartes—but also historical studies offer ground on which the splendid critical work of Mach, for example, has been raised. The author quotes the words of Mach:[1] "Those that know the entire course of the development of science, will, as a matter of course, judge more freely and more correctly of the significance of any present scientific movement than those who, limited in their views to the age in which their own lives have been spent, contemplate merely the momentary trend that the course of intellectual events takes at the present moment." Dr. Sarton then discusses the educational point of view and the point of view of individual and collective psychology, and concludes that *Isis* will strive: (1) to make the elaboration of a manual of the history of science possible; (2) to encourage the production of scientific text-books in which the matters are treated in the historical order of their development; (3) to prepare the sociological synthesis of humanity; (4) to reform, on deeper and firmer bases, the work of Comte.

The other articles are a note by I. Guareschi on the history of the movement discovered by Sir Robert Brown in 1827 of the particles contained in the pollen of plants; a note on the origins of science by G. Milhaud; and a biography of Paracelsus by E. Radl. There is an obituary notice of Poincaré, a portrait of whom is a frontispiece to this number; and there are notes on projected books and congresses, and analyses of published books. Finally a very important bibliography of the publications relating to the history of science which have appeared since the beginning of 1912 is started here. Where possible, publications are arranged in order of time, so that a first step is made towards the exhibition of the influences of the contemporary sciences on one another. It will be seen that the ideal of this new magazine has many points of contact with the ideal of *The Monist,* and we wish the new journal every success and shall make a point of collaboration with it for what ends are in common. Φ

[1] *Mechanics,* 3d. ed., Chicago, 1907, p. 7.

BOOK REVIEWS AND NOTES.

LIFE IN THE MAKING. By *Loren B. MacDonald.* Boston: Sherman, French & Company, 1911. Pp. 223. Price $1.20 net.

The author, who is a disciple of William James, endeavors to establish religion on the basis of pragmatism. He calls his effort in a subtitle "An Approach to Religion Through the Methods of Modern Pragmatism." In the foreword Mr. MacDonald says:

"That religion bears some message of supreme value to human life is an assumption, more or less explicit, in all the great historic faiths. It has been taken for granted that in some way or other man's life on earth is safer, worthier, happier with religion than without it. All the more unfortunate it seems, therefore, that this desirable treasure should have been offered to man at the price of an intellectual sacrifice which he is sometimes not willing to make. Must the only entrance to a temple so beautiful and inspiring always be that of some difficult creed or doctrine? Shall man forever be expected to perform some strenuous, and to many, impossible, mental feats in the form of belief and assent before he can enter in and enjoy its harmonies? He is not called upon to yield that intellectual tribute at the shrine of other great emotional or spiritual interests. Art and music, for instance, do not demand any humiliation on the part of reason and intelligence before they come with their blessed ministry to human needs. Why should not the religious interest, supposed to be of far more significance to life than these, offer its ministry on terms equally acceptable?"

His relation to pragmatic philosophers he expresses thus:

"In a humble, but earnest attempt to depict such a pragmatic form of religion in the following pages the author does not wish to involve any one else in whatever misrepresentations or logical defects of which the attempt may be guilty. While acknowledging his indebtedness to the chief expounders of philosophical pragmatism, and especially to Prof. William James, at whose feet, both in college and out of it, it has been his good fortune to sit as a humble learner, he does not claim their authority for more than the bare suggestions of the opinions here expressed."

The chapters of the book are naturally more sermons than expositions. They are written in a tone of prophetic ecstasy and are entitled respectively Life Simplified, Life Rationalized, Life Revealed, Life Under Orders, Life Shared, Life Spiritualized, Life Made Whole, Life Strengthened, Life Creative, Life in Reserve, Life Re-Enforced, Life Triumphant.

In the conclusion he pictures "the ideal of a church that may sometime be founded on the pragmatic principle in religion." K

GESCHICHTE DER DEUTSCHEN NATURPHILOSOPHIE. Von *Dr. Carl Siegel.* Leipsic: Akademische Verlagsbuchhandlung, 1913. Pp. xv, 390.

It was originally the author's intention to give a picture of the modern natural philosophy movement, the movement represented by Mach and Ostwald, Helm, Riehl and Verworn. He has for many years collected material for such a study, in which a sketch of the German natural philosophy of the last four centuries should occupy the position of an introduction. His decision to enlarge this introduction into an independent treatise and to publish it separately must be welcomed, as the only work that treats historically of this movement, that of Julius Schaller, is 70 years old. The author is concerned with natural philosophy in the narrower sense. He characterizes it as "a scientific discipline which appears consciously by the side of and after natural science, not as a mere possibility after it, but as a necessity, simultaneously with it, demanded by it as an indispensable supplement."

This science, appearing by the side of the science of nature, he divides in two parts, to some extent overlapping in the case of individual authors, but still possible of juxtaposition: the metaphysical, which has the same object as science, namely nature, and is represented by Leibnitz, Goethe, Schelling, etc., and the critical, represented by Kant, Mach and the writers of the present day and whose object is not nature itself, but the science of nature.

After an introductory chapter dealing with the predecessors of Leibnitz: Copernicus, Paracelsus, Agrippa von Nettesheim, Jacob Boehme and Kepler, the author devotes one chapter to Leibnitz from whom he dates the continuous development of natural philosophy in Germany; after him come Kant and Fries, thereafter Herder, Goethe, Schelling and Schopenhauer, and after these follows a consideration of the opponents to the last mentioned: Herbart and Feuerbach. The next to the last chapter is given up to a consideration of the predecessors of the modern movement, Lotze and Fechner, while the last chapter is a summary treatment of the moderns, including a consideration of the influence of the Darwinian theory and the discussion that has taken place around it. In the latest modern development, Ostwald's "qualitative energetics," the author sees an interesting resurrection of Leibnitz's dynamism, though not directly descending from it.

In connection with this work it might be well to call attention to the organ of the modern natural philosophy, *Annalen der Naturphilosophie,* founded by Wilhelm Ostwald as an organ of the common ground of philosophy and natural science. With the volume for 1913 it takes the name *Annalen der Natur- und Kulturphilosophie,* which does not denote a further development of the plan of the journal, but characterizes more clearly its original aim and purpose. The volume now completed (1912) contains, like the previous ten, a number of interesting and significant articles, among which attention might be called particularly to G. C. Hirsch's "Goethe als Biologe," E. Dittrich's "Das Weltbild im Riemannschen Raum," the first installment of S. v. Prowazek's "Die organische Welt und Naturphilosophie." The editor contributed the initial article, an estimate of the life work of Ernst Abbe, called "Abbe unser Führer."—A. G. S. Josephson.